KPMG

Embodied carbon in India infrastructure: An opportunity to reduce more than 2 Giga Tonne emissions

An imperative for India to reach net zero by 2070

A Pre- COP release

kpmg.com/in

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Foreword

The construction industry stands at a critical juncture in the global fight against climate change, particularly in developing nations like India where rapid urbanisation and infrastructure development are reshaping the landscape. While operational energy efficiency has garnered significant attention over the years, the role of 'Embodied Carbon' remains an often-overlooked component of the construction sector's carbon footprint.

To ensure a sustainable future, it is imperative that fast developing countries like India prioritizes the reduction of embodied carbon in building practices and advocate for its inclusion in the agenda of upcoming COPs.

In India, the scope and scale of embodied carbon emissions are profound, especially in light of the ambitious infrastructure developments laid out under the National Infrastructure Pipeline (NIP). With more than USD 1,900 BN[1,2] earmarked for projects in energy, transportation, social and industrial infrastructure, there is an urgent need to address the embodied carbon being locked into these long-term assets. Failure to do so will compromise not only the national climate targets but also global efforts to limit temperature rise and mitigate the impacts of climate change from the infrastructure sector.

This report is next in series to our previous publication on Embodied carbon management for global infrastructure released in March 2023, and delves deeper into the importance of managing embodied carbon within the Indian construction sector. It establishes the potential share of Indian construction sector in remaining carbon budget, magnitude of embodied emissions tied to ongoing and future infrastructure projects, revealing the critical need for policies, guidelines, codes and standards that mandate low-carbon approaches across the industry. Furthermore, it examines a range of emission reduction strategies and pathways for cement and steel (the major contributors for embodied carbon emission on any project) that can be adopted to minimize the environmental footprint of India's burgeoning infrastructure and associated digital interventions required further for scalability and efficiency.

As India seeks to balance economic growth with environmental sustainability, the insights provided in this report will hopefully inspire greater awareness and action towards reducing embodied carbon in construction, setting the foundation for a low-carbon future.

We would also like to extend our sincere gratitude to some of the industry experts who have expressed their views in this report emphasising the urgency of addressing embodied carbon in construction.

Anish De

Partner, Global Head of
Energy, Natural Resources
and Chemicals
KPMG International

Yash Pratap Singh

Partner, Major Projects Advisory,
Business Consulting
KPMG in India

1. Capital expenditure outlay for 2022-23 increased sharply by 35.4 %, Press Information Bureau (pib.gov.in), Ministry of Finance, January 2023
2. National Infrastructure Pipeline: Invest in Infrastructure Projects in India | IIG (indiainvestmentgrid.gov.in), Ministry of Commerce and Industry

Table of contents

01

Introduction: Why embodied carbon matters for India

1.1 Why embodied carbon matters

Embodied carbon refers to the emissions associated with the extraction, manufacturing, transportation, construction, installation, maintenance and end of life stage of building materials. Unlike operational carbon emitted during the asset lifecycle, which can be optimised by increasing energy efficiency, embodied carbon needs to be planned and managed effectively right from the early stages of asset construction. Once emitted, embodied carbon gets locked in with the construction, leaving carbon capture and sequestration as a few limited options available to reach net zero.

> **With the rising development need and associated infrastructure growth globally, there is a two-fold projected increase of embodied carbon emission share by 2050 from new construction[3]. There is a heightened merit in focusing on the environmental impact of materials before their consideration on a new project.**

Measuring, baselining, and tracking embodied carbon in construction projects are one of the biggest challenges we face now for industry decarbonisation, mainly attributed to the fragmented nature of construction value chain. Though the increased focus and policy requirements to address this issue is gradually encouraging the concerned stakeholders to take the right first steps. This is witnessed by a sharp rise in alternate materials innovation, digital calculators for embodied carbon, and adoption of low carbon construction methods. However, a collective thinking from the construction ecosystem is still absent.

3. KPMG in India secondary analysis over WGBC report on Bringing embodied carbon upfront, 2019

While efforts in low carbon construction are increasing, the downstream adoption rate has been muted, especially in developing geographies such as India due to the following major reasons:

- Lack of awareness and education
- Limited supply chain integration
- Propensity towards low-cost construction
- Scope 3 tracking challenges
- Regulatory compliance challenges
- Market fragmentation
- Reliance on traditional practices
- Implementation challenges on ground

With focus on infrastructure, the Government is likely to play a prime role in shaping the pathways for low carbon infrastructure. With the dual role of a consumer and a standard governing body in the construction sector, the Government can influence industry stakeholders by bringing in both incentives and mandates.

Incentives

Tax credits and rebates

Tax incentivisation for use of low carbon materials include tax deductions for the cost of materials or credits for emissions reductions

Grants and subsidies

Direct financial support to incorporate low carbon materials, making them more financially viable

Building certifications

Promote certifications such as BREEAM, USGBC, UKGBC, WGBC, IGBC, GRIHA and others which incentivize the use of low carbon materials.

Preferential procurement policies

Government contracts mandating the use of low carbon materials, catalysing the market for low carbon products

Mandates

Building codes and standards *(Short term)*

Mandate the use of low carbon materials through building codes and standards

Reporting and transparency *(Mid term)*

Mandating disclosure of carbon content of their materials and penalizing non-compliances

Carbon Pricing and Emissions Trading Scheme *(Long term)*

Inhibit the use of high carbon construction material by putting a price on carbon emissions and making their use expensive

1.2 Tying together India's story of economic growth, net zero goals and an opportunity to lead embodied carbon reduction

It is well established that India is the fastest growing major economy and poised to become the world's third-largest by 2027.[4]. With a commitment to reduce projected carbon emissions by one billion tonnes by 2030 and achieve net-zero emissions by 2070, India recognizes the need to balance economic growth with environmental responsibility [5].

Surpassing the European Union in total annual greenhouse gas in 2019, India is currently the third largest emitter of carbon dioxide after China and The United States. Despite this, its per capita emissions are significantly lower due to its large population[6].This population is expected to grow and is expected to peak in 2064[7] requiring significant infrastructure growth.

Infrastructure will play a key role in concurrently maintaining the economic growth and accommodating the growing population. The Government's focus on building infrastructure of the future has been evident given the slew of initiatives launched recently such as the "Gati Shakti", which is a USD 1.3 trillion national master plan.

This positions India uniquely with a diverse set of both challenges and opportunities. The country needs to address substantial carbon emissions associated with the infrastructure growth, clubbed with the complexity and temporary nature of stakeholder relationships in construction lifecycle. More importantly, by addressing the embodied carbon proactively, the country commands potential to shape the global value chain.

India's construction sector challenges

- Financial constraints: Funding challenges & cost overruns
- Diverse stakeholders and skill shortages
- Low adoption rate of emerging technologies
- Regulatory compliances and legal disputes
- Project management issues and infrastructure bottlenecks
- Health, Safety and Environment practices

How India can play a central role in the global construction value chain

- ***India's economic and industrial base*** is one of the fastest growing in the world. Adopting low carbon technology and practices now can set a precedent for developing nations
- ***Complying with and promoting the International policy regime*** *that requires embedded emissions reporting (especially for FDIs and global trade)*
- ***Developing innovation hubs at global level*** for low carbon material research and technology development
- ***Leveraging the huge renewable potential*** to decarbonise the grid and reduce the carbon footprint of energy intensive industries
- ***Unlocking the potential of circular economy models,*** where one sector's waste becomes another's raw material, paving the way for development of innovative alternate construction material

4. India Will Grow To Become The World's Third-Largest Economy By 2027, Forbes, February 2024
5. India is committed to achieve the Net Zero emissions target by 2070, Ministry of Science & Technology, PIB Delhi, September 2023
6. 9 Charts Explain Per Capita Greenhouse Gas Emissions by Country, World Resources Institute, May 2023
7. World population forecast to peak at 9.7bn in 2064 then shrink by 2100, The Lancet, University of Washington, USA, July 2020

1.3 Share of Indian construction sector in remaining carbon budget

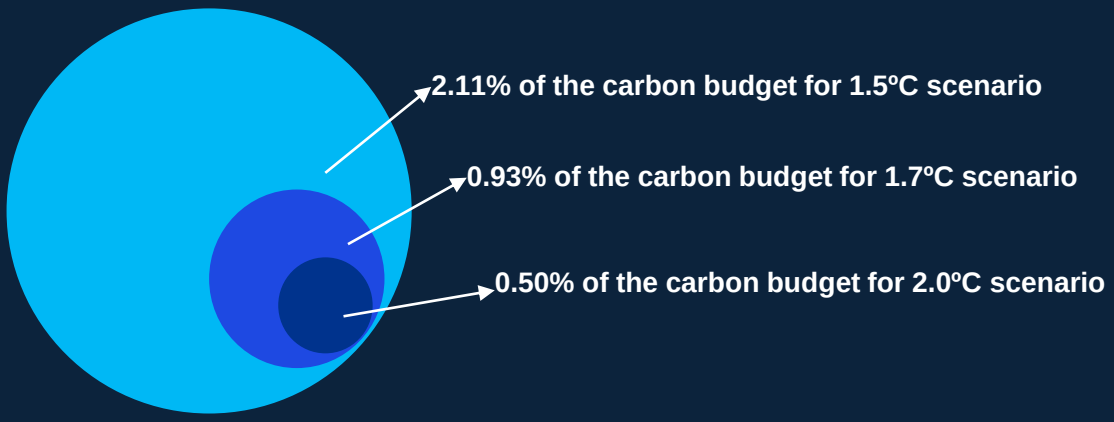
1.3.1 Global and India's balance carbon budget

According to the IPCC's report,[8] limiting human-caused global warming requires net zero anthropogenic CO2 emissions. Pathways consistent with 1.5°C and 2°C carbon budgets imply rapid, deep, and in most cases immediate GHG emission reductions in all sectors.

As per KPMG in India analysis, during the period of 2024 to 2030 alone, the Indian construction sector with the expected growth rate of 6.5% CAGR,[9] it will be responsible for 5.80 GtCO2eq.[10]

The remaining carbon budget for a 50 % likelihood to limit global warming to 1.5ºC, 1.7ºC, and 2ºC are 275 Gt CO2, 625 Gt CO2, and 1150 Gt CO2, respectively, from the beginning of 2024[11]

The share of Indian construction sector's embodied carbon will be significant in all the scenarios.



Share of Indian construction sector in remaining carbon budget.[12]

8. AR6 Synthesis Report: Climate Change 2023, IPCC, March 2023
9. Forecast Average Annual Growth Rates 2023-2030, Data Based Analysis, 2023
10. KPMG in India analysis analysis based on Forecast Average Annual Growth Rates 2023-2030, Data Based Analysis, 2023
11. GCB 2023, Global Carbon Project, December 2023
12. KPMG in India analysis based on GCB 2023, Global Carbon Project, December 2023

1.4 What industry experts have to say

KPMG in India has conducted multiple panel discussions with industry experts, which focused on the rising need to address embodied carbon in buildings and infrastructure sectors. The perspectives shared by various participants bring out different themes for collective actions.

Cost and Carbon Link

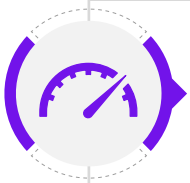
Stakeholders need to evaluate projects using a dual lens that accounts for both addressing carbon emissions and the cost-benefit in adopting emission curbing measures

Policies and Guidelines

- There is an urgent need for stringent carbon laws encompassing all aspects of the project lifecycle in the Construction projects. Line Ministries to be engaged for legislative actions.
- Setting up standards for measuring embodied carbon can be a right starting step to develop specific taxonomies and their associated frameworks which India currently lacks

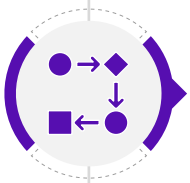
Technology Intervention

Digital capture of emission data at various stages of construction can help catalyse benchmarking of projects based on embodied carbon emissions



Carbon Measurement

Increased awareness and incentivization for declaring Environmental Product Declarations (EPDs) by Indian manufacturers will increase transparency in the construction value chain



Process Improvements

An equilibrium needs to be maintained between infrastructure development and the net zero aspirations. Even though policies and codes may take time to develop, projects need to incorporate sustainable practices today and measure their emissions, and set benchmarks

All the five themes emerging from the discussions are of utmost importance for achieving net zero in construction. Complementing to these themes, the immediate next steps should address the challenges around **data streamlining for carbon measurement, formulation of a baseline directory and financing needs** to take carbon conscious decisions.

Safety aspects cannot be compromised while addressing embodied carbon emissions. Setting up of Key Performance Indicators (KPIs) can help stakeholders take the right decision to achieve the carbon vs. resilience balance.

Mili Majumdar
Managing Director, GBCI India and
Senior Vice President, Research
and Innovation, USGBC

Presence of **frameworks to capture emission** data at various stages of construction can help catalyse benchmarking of projects based on embodied carbon emissions

Santhosh Muzumdar
Director of Government
Relations and Sustainability
Johnson Controls

Embodied carbon for many hard-to-abate industries is heavily impacted by procured goods and services. A robust **value chain partner engagement program** and **supply chain decarbonization plan** is paramount to its effective reduction and Race to 'Net-Zero' goal.

Kalyan Bhattacherjee
Chief Sustainability Officer,
Jindal Stainless Limited

The buildings and infrastructure we create today will have far-reaching environmental impacts that extend well beyond their operational lifetimes. For a sustainable future, it is **imperative to address embodied carbon which is an often-overlooked aspect**, through innovative materials, advanced construction techniques, and developing associated validation/certification standards. By doing so, we not only mitigate our near-term carbon footprint but also **set a precedent for future development**.

Shubha Shanbag
Head ESG, IndoSpace Development
Management Pvt. Limited

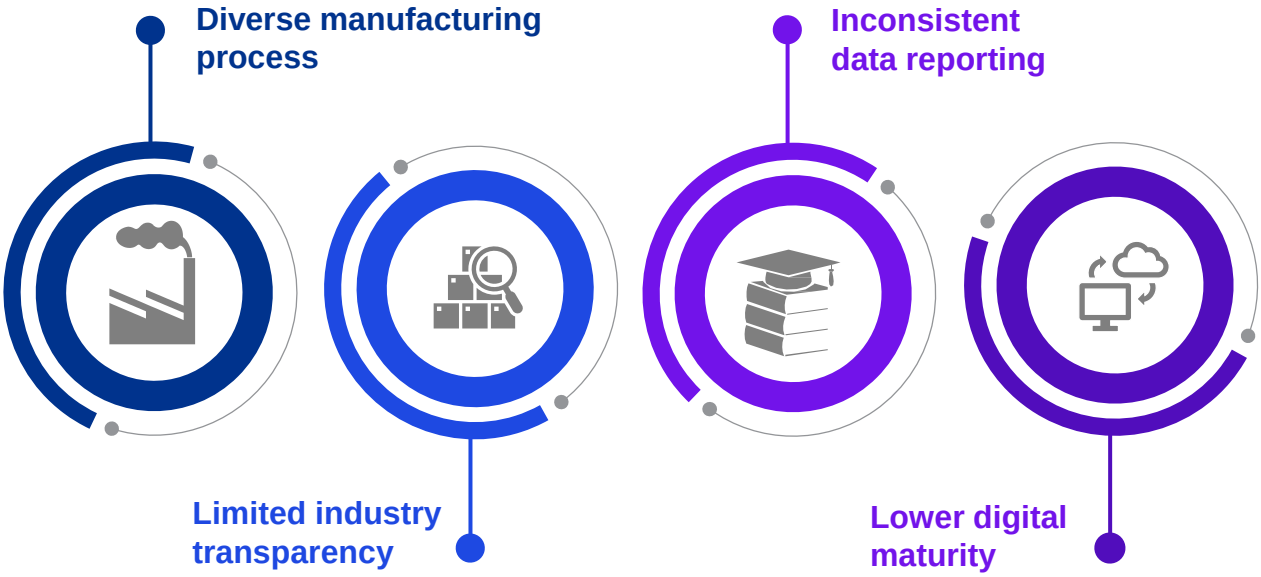
Whole life Carbon is a true measure of the environmental footprint of any development; hence, **organizations need to start evaluating projects from this lens of Total Carbon** to achieve the ultimate aim of carbon neutrality. Accordingly, operational carbon emission optimization should be treated as a short to medium term goal in Indian context, while keeping a watch on the emerging embodied carbon policies & codes. The organizations should also **set up a process of continuous measurement of their carbon emissions** thereby creating a benchmark, which shall be useful to evaluate the effectiveness & impact of sustainable practices adopted during their journey towards carbon neutrality.

Ashish Rakheja
Managing Partner,
AEON Integrated
Building Design Consultants
LLP

1.4.1 Streamlining data for carbon measurement in construction projects

The initial steps for addressing embodied carbon is measuring the upfront Green House Gas (GHG) emission during project evaluation stage, which is dependent on actual emission measurements or having material EPDs, and the supply chain data. This is subsequently followed by comparison with other available design and material alternatives; assessing the overall performance; setting allowable limits; and further reducing emissions systematically or setoff through carbon credits, capture and sequestration, etc.

India as a developing Infrastructure nation has a tough road ahead in assessing embodied carbon, owing to data challenges largely attributed to following factors:



Variability in data quality and availability across sectors, especially in smaller enterprises, hinders accurate measurements. Additionally, addressing data gaps by capturing learnings from global best practices and promoting a standardized methodology for measurement through a nationally defined policy would contribute to a more comprehensive understanding and measurement of the carbon footprints across different infrastructure sector projects.

1.4.2 Formulation of an emission baseline directory

Another most important step in reduction of embodied carbon on a large scale would be to empower stakeholders with data, professional expertise, and resources needed to evaluate, compare, and adopt alternate materials, assess embodied carbon, and find skilled professionals to guide the transition. This can be done through carbon baselining measures:

1. **Directory of alternate materials:** Catalog sustainable building materials and their availability across India. Key Components:
    a. **Material types:** Low-carbon options like bamboo, recycled steel, eco-friendly concrete and others
    b. **Regional availability:** Data on where materials are manufactured or supplied
    c. **Suitability & performance:** Application of materials with details on strength, cost, and durability.

2. **Directory of emission factors for Indian buildings:** Establish emission baselines for typical Indian construction to assess potential carbon savings with alternative materials. Key Components:
    a. **Building types:** Residential, commercial and infrastructure
    b. **Emission factors:** Standard values for materials like cement, steel, bricks, etc.
    c. **Regional variability:** Adjustments based on local building practices and climate.

3. **Embodied carbon data:** Provide embodied carbon metrics to compare different building materials. Key Components:
    a. **Carbon data:** Embodied carbon for materials like concrete, steel, bamboo
    b. **Comparison:** Show carbon savings potential by using alternate materials
    c. **Lifecycle impact:** Consider the carbon footprint from extraction to disposal
    d. **Case studies:** Documented examples of carbon reductions in real projects.

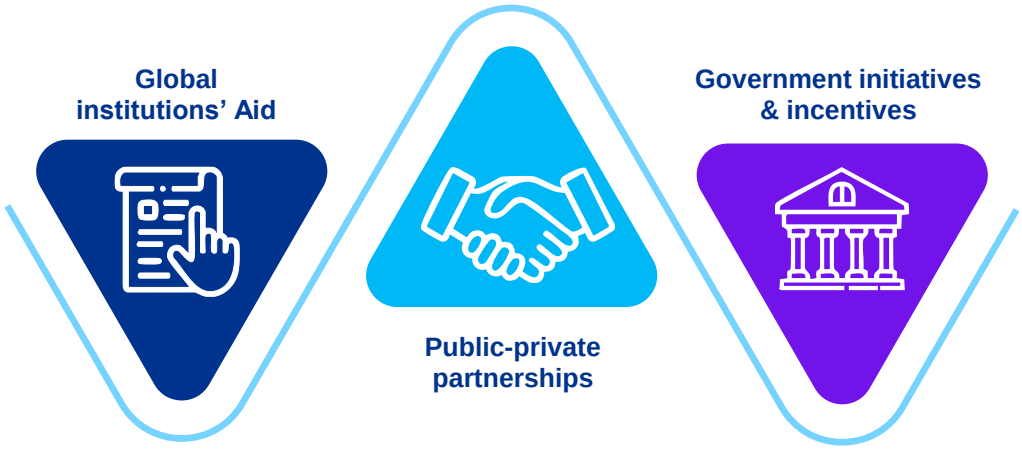
4. **Directory of accredited professionals:** Connect businesses with experts in sustainable building and low-carbon transitions. Key Components:
    a. **Consultants & Design agencies:** Specialists in green building practices
    b. **Certification bodies:** Organizations for LEED, GRIHA, and other green certifications
    c. **Skill transfer:** Companies providing training for sustainable construction skills.

These measures could benefit in terms of a) informed decision making to stakeholders in choosing low-carbon materials and track carbon savings, b) industry transition through support for businesses in adopting sustainable practices through access to data and accredited professionals and c) achieve scalability tailored to regional availability and building practices in different parts of India.

This will further require collaboration involving industry, academia, and government for accurate data, creation of a digital platform in terms of online directory which is accessible to all and conduct pilot projects to test and document the effectiveness of low-carbon materials.

1.4.3 Financing needs

Thirdly, reduction of embodied carbon on a large scale would demand additional capital for the requisite measures. Financing such initiatives in India can be a catalyzer with a multi-faceted approach. Following levers would play a key role:



A. Public-private partnerships (PPPs) are crucial for addressing the financing needs in India for several reasons:

Resource pooling: PPPs allow public and private resources to come together, leveraging government funding with private sector investment. This expands the financial capacity to undertake large-scale projects aimed at reducing embodied carbon

Risk sharing: Sharing risks between public and private entities can mitigate financial uncertainties associated with implementing new technologies or processes to reduce embodied carbon. This can encourage private sector involvement by providing a more stable investment environment

Innovation and expertise: Private sector involvement brings innovation and expertise in technology and project management, enhancing the efficiency and effectiveness of carbon reduction initiatives. Collaboration between public and private entities can lead to the development and adoption of cutting-edge low carbon solutions

Policy alignment: PPPs enable alignment between government policies and private sector interests, fostering an environment conducive to sustainable development and carbon reduction goals. This alignment can facilitate the implementation of regulatory frameworks and incentives to promote green investments

Scalability and sustainability: PPPs facilitate the scalability and sustainability of carbon reduction initiatives by combining public sector oversight and planning with private sector operational efficiency and market-driven incentives. This ensures that projects are not only implemented but also maintained over the long term.

B. Government initiatives and incentives would enable financing in following ways:

Regulatory frameworks: Streamlining frameworks that gradually mandate the reduction of embodied carbon. These regulations can create a favorable environment for sustainable practices and technologies

Incentives: Offer incentives such as subsidies, tax breaks, and rebates that will make low carbon projects more economically viable. These incentives can encourage businesses to invest in eco-friendly technologies and practices

Direct investments: Investment by the government in infrastructure and technology can kickstart projects that reduce embodied carbon. This can include funding for research and development, pilot projects, and the deployment of renewable energy sources.

C. Collaborations with global institutions/ organizations would not only benefit Indian industries in green financing but will also help improve the learning curve significantly to deal with the situation.

Funding and grants: International aid organizations and development banks can provide significant funding in the form of grants, green bonds, low-interest loans, or technical assistance. These funds can be directed towards projects aimed at reducing embodied carbon in various industries

Expertise, knowledge transfer and capacity building: Collaborations with international organizations bring in global expertise and best practices. This can help Indian industries adopt state-of-the-art technologies and methodologies for measuring and reducing embodied carbon. Such partnerships often include training programs and capacity-building initiatives, which can enhance the skills and knowledge of local stakeholders, ensuring sustainable implementation of carbon reduction strategies.

Addressing the financing needs for reducing embodied carbon in India requires a coordinated effort. A comprehensive strategy aligning economic goals with environmental sustainability has thus become essential.

1.4.3.1 Effective well governed stakeholder collaboration and investment in low-carbon expertise can unburden the cost implications of low carbon sustainable infrastructure and facilitate the passing-on of benefits to end users

Addressing the higher cost of low carbon infrastructure

Benefactor

The Government Regulatory Bodies

Beneficiaries

Clients & Owners
Contractors
AECs
Suppliers/ Vendors

- **Financial incentives and support:** Government support systems such as subsidies and grants; tax incentives; low-interest loans and green bonds will encourage the switch to low carbon infrastructure
- **Market-based mechanisms:** Carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems can create economic incentives to reduce carbon emissions; green building certifications can help builders command higher market prices
- **Technical and logistical support:** Continuous investing in R&D and providing training programs / assistance can catalyse the development of alternate low carbon materials and construction methodologies
- **Regulatory and policy support:** Updating building codes / standards, and governments using their purchasing power can drive demand for low carbon materials
- **Collaborative efforts:** Industry collaboration and public awareness campaigns on low carbon infrastructure can encourage market demand, making it easier for companies to justify investment in such assets.

Passing on the benefits of low carbon infrastructure to end users

Benefactor

Clients & Owners
Contractors
AECs
Suppliers/ Vendors

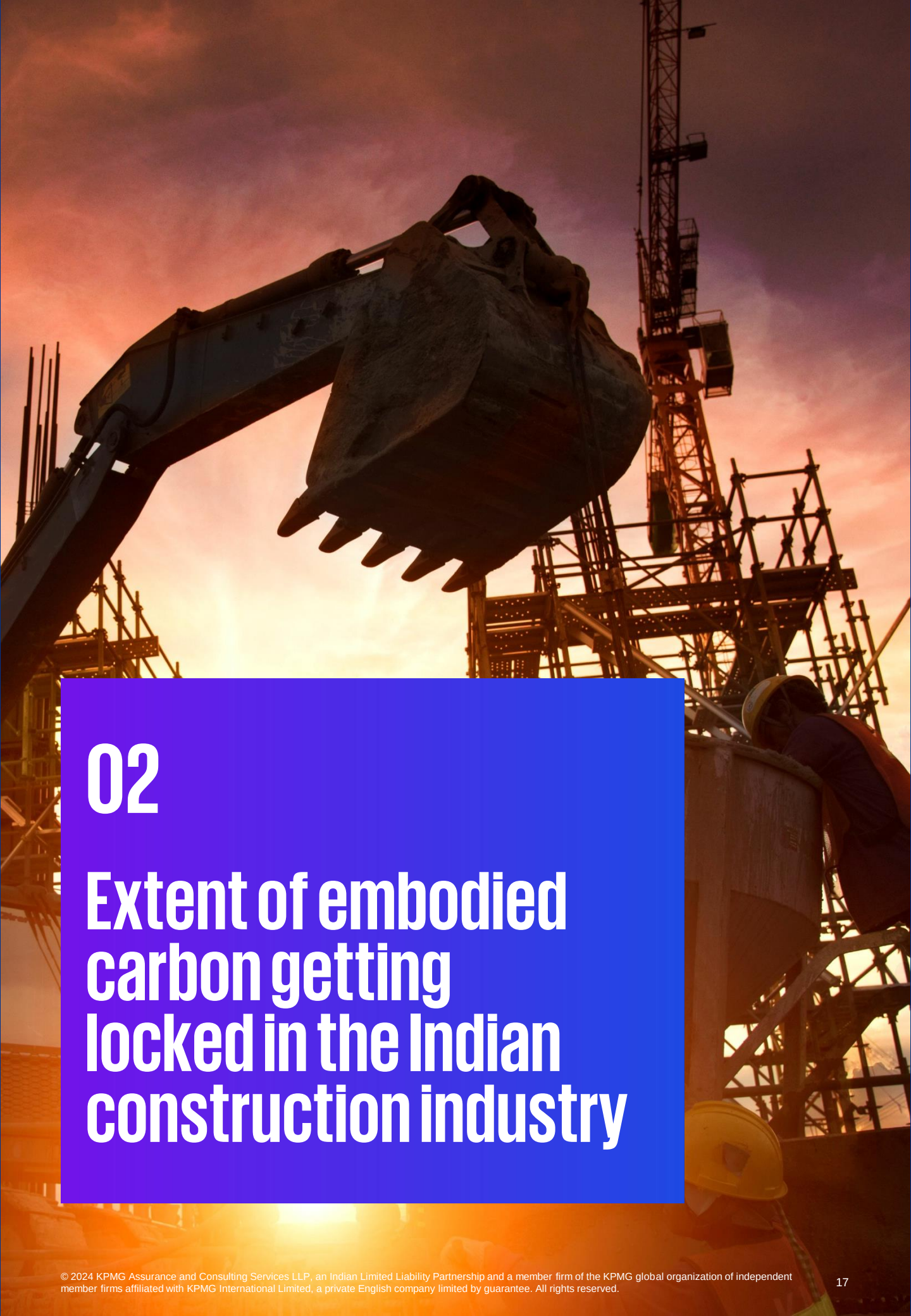
Beneficiaries

End Users

- ***Lowered operating cost:*** Energy-efficient buildings and infrastructure (utilizing low carbon construction material like mass timber, straw insulations, vacuum insulation panels made from natural fibres etc.) can significantly lower utility costs by reducing the cooling / heating requirements and in turn reducing utility and maintenance costs

- ***Financial incentives and rebates:*** End users can benefit from government incentives such as rebates, tax credits and lower interest rates on loans for energy-efficient infrastructure, reducing borrowing costs for end users

- ***Higher resale value:*** Properties with low carbon infrastructure can have higher resale values due to their energy efficiency and sustainability features.

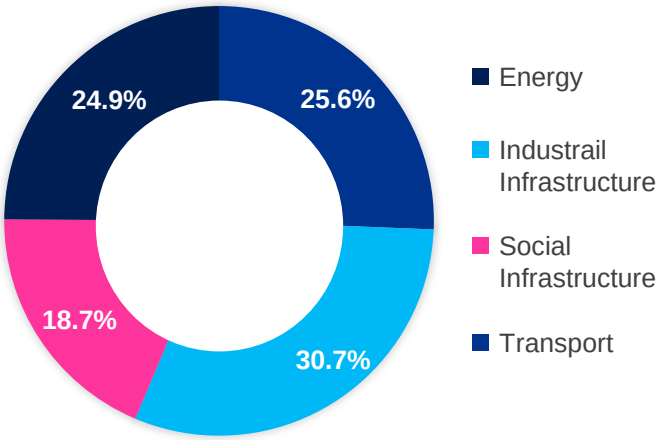


02

Extent of embodied carbon getting locked in the Indian construction industry

2.1 India's embodied carbon forecast with the infrastructure growth

Graph 1: National Infrastructure Pipeline investment split[15] in four major infrastructure categories



Industrial infrastructure constitutes approximately 1/3rd of the infrastructure spend and should be considered a priority sector for embodied carbon reduction

For detailed list and classification please refer to Annexure.

Approximately 73% of NIP investments are considered for our analysis[15]

Capex oriented projects in these sectors from the National Infrastructure Pipeline present an opportunity of embodied carbon reduction in three phases:

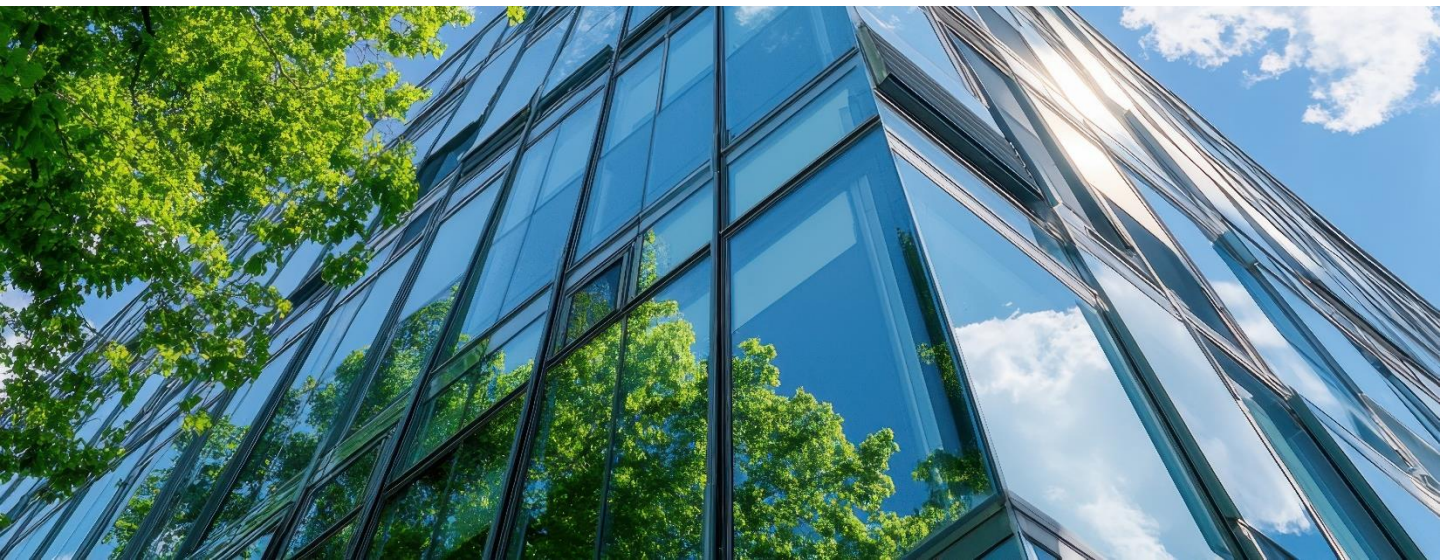
- Planning approx.100% of the embodied carbon reduction (with an option to use existing infra or plan for complete carbon emission offset)
- Design phase ~ 80% (with use of low/ no carbon substitutes like agrocrete, hollow core slabs, mass timber etc.)
- Construction phase ~50% (Use of renewable energy for construction, electric equipment, etc.).

It is assumed that NIP projects have a distribution amongst these three phases as:

- Planning ~ 40% of embodied carbon through NIP projects rests in this phase
- Design ~ 30% of embodied carbon through NIP projects rests in this phase
- Construction ~30% of embodied carbon through NIP projects rests in this phase.

Using the above two conditions embodied carbon emission is projected under these three phases and bucketed under two classifications (Opportunity loss, Potential)

13. Capital expenditure outlay for 2022-23 increased sharply by 35.4 %, Press Information Bureau, Ministry of Finance, January 2023
14. National Infrastructure Pipeline: Invest in Infrastructure Projects in India | India Investment Grid, Ministry of Commerce and Industry, June 2023



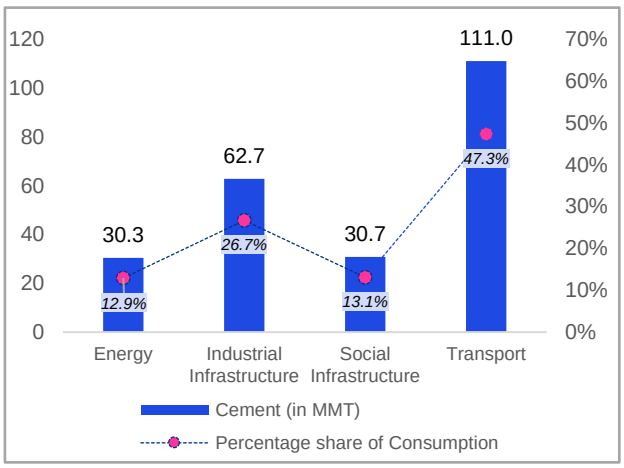
Current infrastructure outlay presents an opportunity of reducing embodied carbon impact by 1.75 to 2 GT in consumption across 80% of The National Infrastructure Pipeline projects

Approx 20% of the opportunity is already lost as per KPMG in India analysis

	Planning [100%]		Design [80%]		Construction [50%]	
	Opportunity Loss	Potential	Opportunity Loss	Potential	Opportunity Loss	Potential
Energy	-	277	42	166	104	104
Industrial Infrastructure	-	295	44	177	111	111
Social Infrastructure	-	47	7	28	17	17
Transport	-	334	50	201	125	125
Total (MMT CO2)						
Potential	1883	953		572		193
Opportunity Loss	500		143		357	

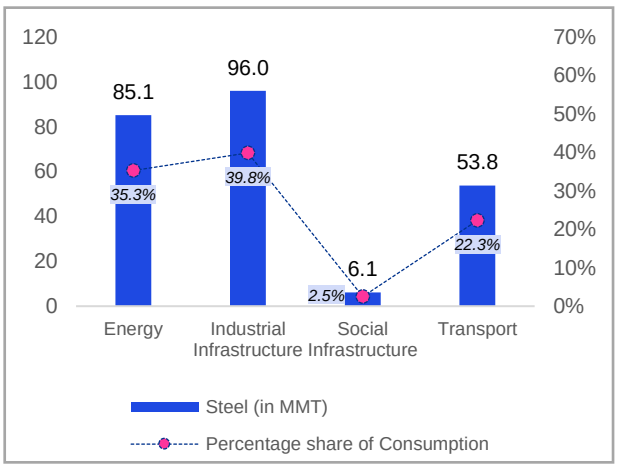
Cement and Steel are the two commonly used material in the construction sector. To fulfill the requirements of the NIP projects alone, significant quantity of cement and steel need to be manufactured.

Graph 2: Cement requirement for capex (in MMT) vs percentage share of total requirement [15]



Transport & Industrial Infra accounting for approximately 80% of emissions due to cement usage

Graph 3: Steel requirement for capex (in MMT) vs percentage share of total requirement [15]

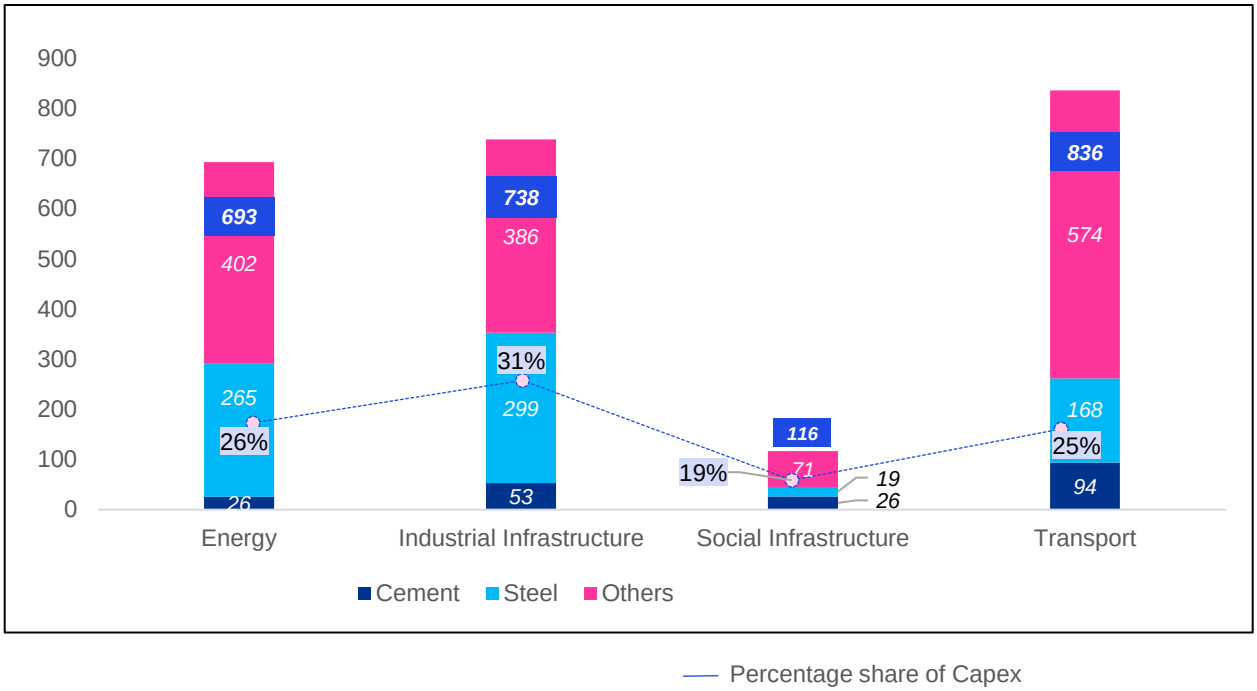


Energy & Industrial Infra accounting for approximately 70% of emissions due to steel usage

15 KPMG in India Analysis based on input from 13, 14, 37, 38 and Annexure

The current steel and cement making processes in India are conventional and emission intensive. Other materials such as glass, aluminum etc., also play a key contributing role in the material-based emissions in construction projects. The graph below shows the approximate projected emissions due to material usage for projects under the various project categories of National Investment Pipeline

Graph 4: Embodied Carbon Emission in MntCO2e due to Cement , Steel and other materials [16]



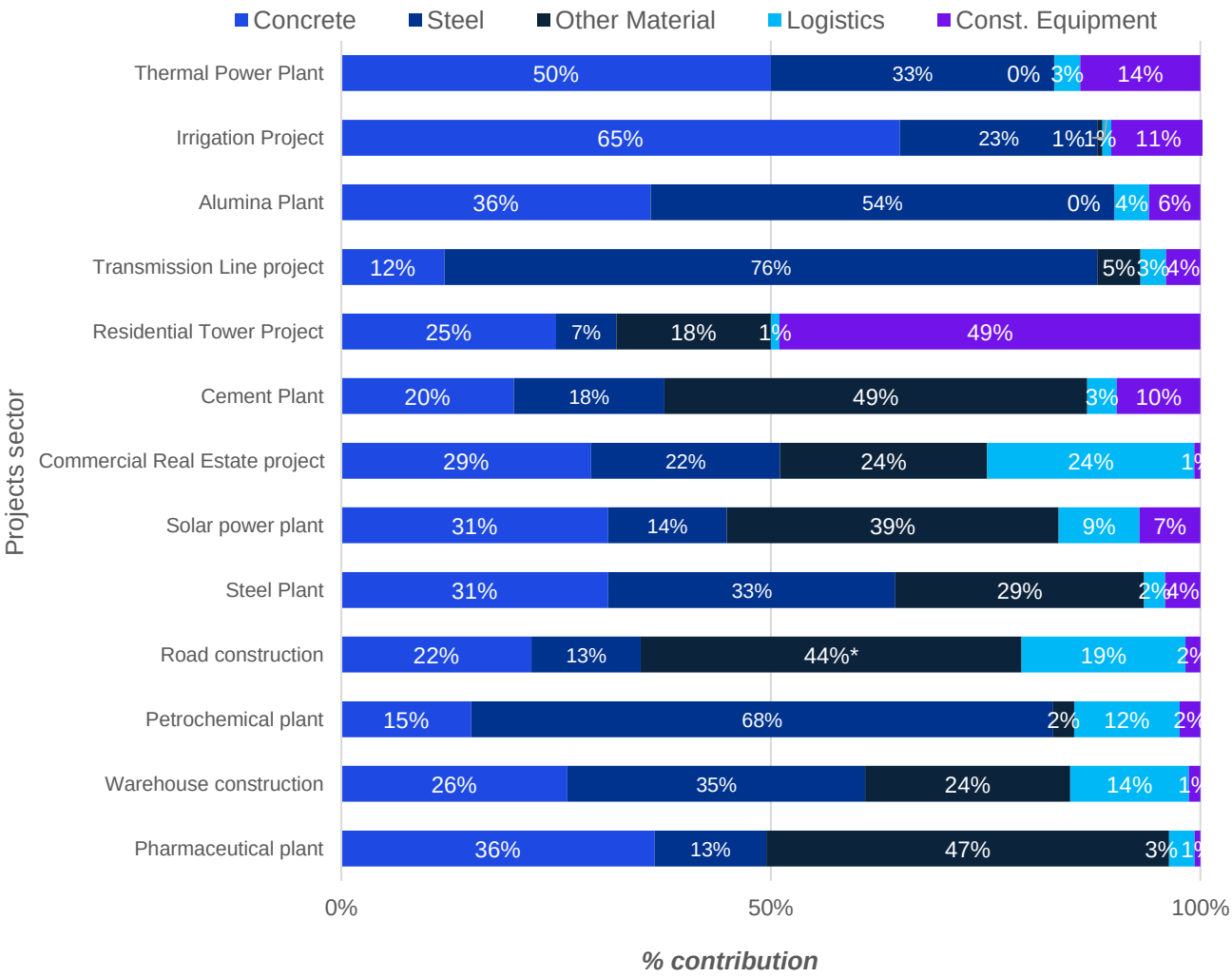
In terms of sector wise breakup, Transport along with industrial and Energy presents us with an opportunity of approximate 2.2 GT of embodied carbon emission.

16 KPMG in India Analysis based on input from 13, 14, 37, 38 and Annexure

2.2 Sectoral outlook

KPMG in India conducted an analysis of sample capital projects across sectors for embodied carbon footprint. The projects' bill of quantities, supply chain and site machinery usage were mapped with carbon factors (as per The Inventory of Carbon and Energy (ICE), a BSRIA guide) of materials and fuels, and the available Environmental Product Declarations. As standard factors have been used, the results may have an estimated accuracy of 70-80%[17].

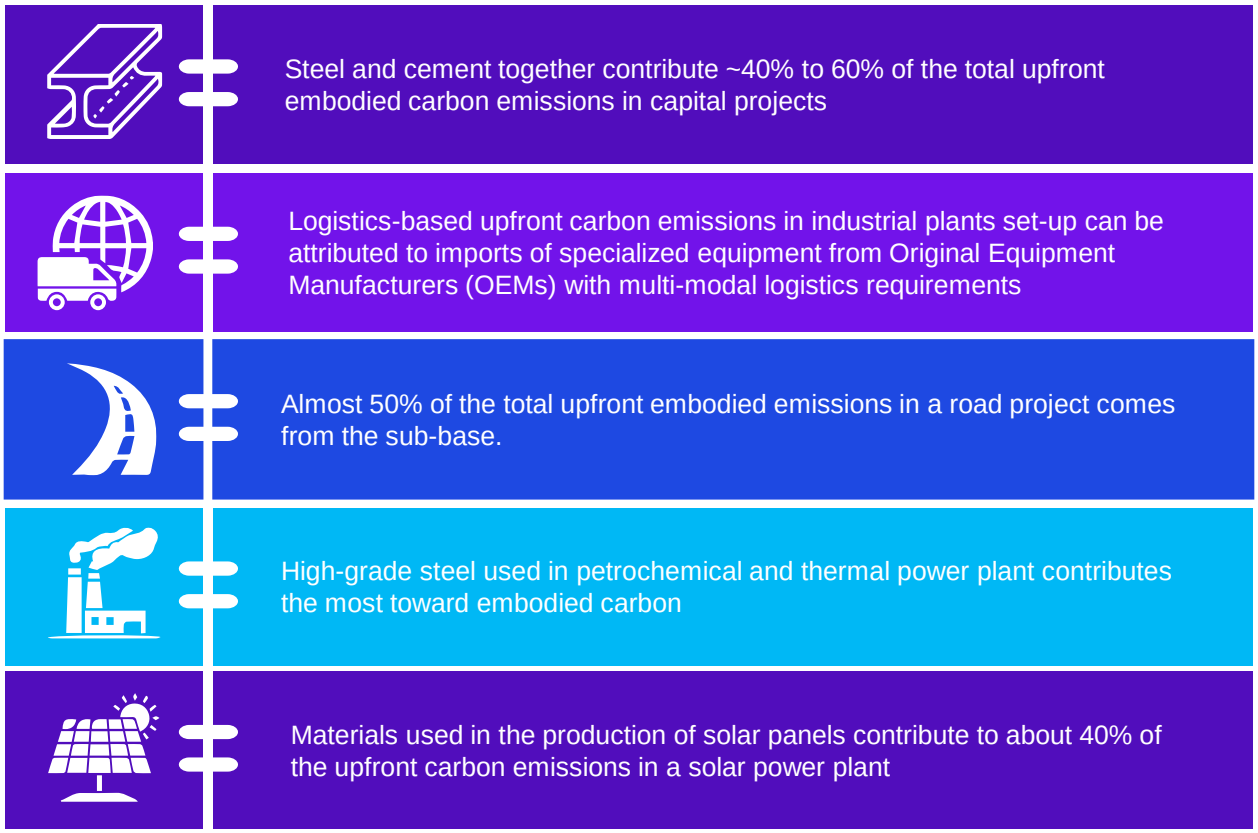
Graph 5: Embodied carbon emissions in capex projects across sectors distributed in terms of material use based, logistics based and construction activity based emissions [18]



Note: *Other materials capture road works (GSB, WMM, DBM and BC)*

17. The carbon factors used for calculations are directly used from the generic carbon factors as mentioned in the Inventory of Carbon Emissions of materials.
18. Environmental Product Declarations for Indian manufacturers, where available were used. Approximate usage of Transport and Construction machineries were considered for evaluations, with 70% - 80% accuracy

Some of the key inferences from our sectoral analysis:



But, not all is grim as India is actively working to reduce embodied carbon emissions in its steel and cement sectors, which are the major contributors of embodied carbon.

In the steel sector, the government has introduced several initiatives[19]. The Steel Scrap Recycling Policy 2019[19] promotes the use of domestic scrap, reducing emissions. The Perform, Achieve and Trade (PAT) scheme[19] incentivizes energy efficiency, and 14 task forces established by the Ministry of Steel are developing a green steel roadmap[19]. The National Green Hydrogen Mission (NGHM) is a key initiative, allocating 30% of its pilot project budget, i.e. INR 14.66 billion (USD 177 million) [20] to promote green hydrogen in steelmaking. Additionally, the European Union's Carbon Border Adjustment Mechanism (CBAM) imposes tariffs on carbon-intensive imports, pushing Indian steel producers to adopt greener practices.

In the cement sector, the PAT scheme encourages energy efficiency in cement plants. The government promotes use of blended cement and supplementary cementitious materials (SCMs) like fly ash and slag, which reduce CO2 emissions. Green public procurement policies incentivize the use of lower-carbon concrete in public projects. The government supports research and pilot projects for carbon capture and utilization (CCU) technologies, aiming to repurpose CO2 emissions from cement production. Emission reduction mandates set carbon intensity benchmarks and targets for the cement sector.

19. Policies To Promote Decarbonisation In Steel Industry; Ministry of Steel – PIB Delhi, 30 July 2024
20. Steel decarbonisation in India; Institute for Energy Economics and Financial Analysis (IEEFA), Vibhuti Garg, Jyoti Gulia, Kapil Gupta, Nagoor Shaik and Shantanu Srivastava, September 14, 2023

03

Ramping up Policy, Codes & Standards interventions

3.1 Policy mandates in India to address the challenge

India's construction sector exhibits remarkable annual growth of more than 6.5% [21], yet it lacks a comprehensive policy to regulate its carbon emissions. Existing measures emphasize on sustainability elements, which are more oriented towards the operational aspects of the asset. This is also in line with the rest of the advanced economies in the world but falls short of addressing the crucial aspect of reducing embodied carbon.

01 **The realization of India's Net Zero Carbon emission target hinges significantly upon the efficacy of existing policy decisions and those yet to be made in near future.**

Few of the existing relevant policies, initiatives, codes and standards in India and their coverage:

Table: Coverage of policies in India around embodied carbon [23]

Policy / Initiatives / Codes and Standards	Rating system	Energy performance / conservation	Sustainable / Green building practices	Address embodied carbon
Energy Conservation Building Code (ECBC)[22]		✓		✓
National Building Code (NBC) of India		✓	✓	✓
Green Rating for Integrated Habitat Assessment (GRIHA)	✓	✓	✓	✓
Indian Green Building Council (IGBC)	✓			
Perform, Achieve, and Trade (PAT) Scheme		✓	✓	
Smart Cities Mission			✓	✓
National Action Plan on Climate Change (NAPCC)		✓	✓	
Model Building Bye-Laws (MBBL), 2016		✓	✓	
Climate Smart Cities Assessment Framework (CSCAF)			✓	
National Mission on Sustainable Habitat (NMSH)		✓	✓	

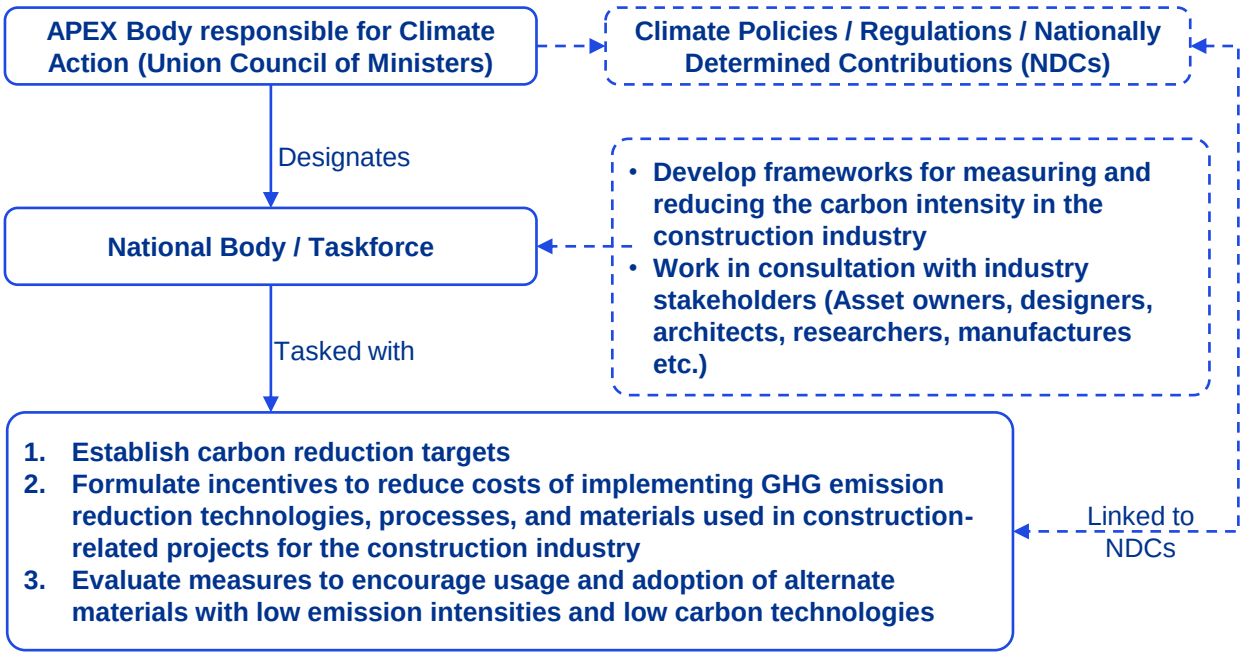
21 Forecast Average Annual Growth Rates 2023-2030, Data Based Analysis, 2023
22. Energy Conservation Building Code (ECBC) | BUREAU OF ENERGY EFFICIENCY, Government of India, Ministry of Power
23. KPMG in India analysis

Although multiple policies, initiatives, frameworks etc. are driving developers towards sustainable practices, only a few of them address embodied emissions. While the focus on operational carbon emissions has increased, there is a dearth of specific options to combat the problem of embodied emissions.

A top-down approach with the Government, mandating policies targeting embodied carbon reduction will serve as a sound initial push. These policies should address the complete construction value chain with phased roll outs focusing on following key enablers:

02 **With stakeholders generally prioritising cost benefits over carbon reduction measures, any deliberate reduction initiatives on a wider scale seem challenging in the near term without Government interventions.**

03 **A top-down approach is required to establish mandates for embodied carbon at National level. An indicative framework is illustrated below.**



A comprehensive framework for embodied carbon reduction should include the following:

1. Broad sectoral reduction ***targets*** with ***timelines***
2. Interim reduction targets with feedback loops to plug in gaps to achieving the overall target
3. Reporting and tracking mechanism
4. Applicability thresholds (Project Size / Invested amount)
5. Feasible[24] and cost-effective[25] action plans
6. Incentives for compliance

Feasibility aspects inclusive of, but not limited to[24]:

1. *Installation*
2. *Health Safety & Performance*
3. *Suitability to address future physical climate risks*
4. *Commercial availability*

Cost Impact aspects inclusive of, but not limited to:[25]

1. *Cost overshoot*
2. *Time delay*
3. *Proximity and availability of local materials*

To incentivize and mandate the adoption of sustainable practices, few of the recommendations that the Government and Private industries may start considering:

a) **Adoption of 'Sustainability', Quality cum Cost Based Selection (SQCBS) instead of prevailing Quality cum Cost Based Selection (QCBS) system during procurement:** Impose the system of qualifying the 'Winning Bidder' in the large-scale construction projects through SQCBS evaluation methodology comprising of Carbon Credit, Technical and Financial Score instead of regular QCBS methodology which is limited to Technical and Financial Scoring only. In case where L1 (Least cost) is the sole criterion, L1C1 (Least cost-Least carbon) should be considered.

b) **Global Warming Potential (GWP) of the Materials** proposed for use in the Construction for PPP Projects can be another criterion, which can be combined with the proposed SQCBS method above.

c) A **Star rating system** (similar to ratings for energy consuming equipment) may be developed and extended to rate the project basis the total emissions of the infrastructure. This can also be merged with the SCQBS criteria.

04 A Potential Star Rating system for embodied carbon

A genuine rating system with defined thresholds for each rating based on embodied carbon emissions against sector specific emission benchmarks can be developed to aid stakeholders, including developers, architects, engineers, and policymakers, in making informed decisions and promoting the use of low carbon infrastructure.

POTENTIAL STAR RATING SYSTEM
A proposed guide

Set industry specific benchmarks for embodied carbon

Develop STAR rating systems

Where higher number of stars indicate lower embodied carbon

Assessment criteria

- **Material selection:** Evaluate the carbon footprint of construction materials used
- **Manufacturing process:** Consider the energy consumption and emissions associated with manufacturing the materials
- **Transportation:** Account for emissions from transporting materials to the construction site
- **Construction practices:** Include the carbon impact of construction activities and techniques
- **Lifecycle assessment (LCA):** Consider the entire lifecycle of the materials, from extraction to disposal or recycling

Key enablers

Standardised measurement: Establish standardized measurement systems such as EPD Framework or ISO standards

Certification and verification: Establish processes and auditing systems for measuring embodied carbon and ensuring compliance

Transparency and reporting: Enforce public disclosure and detailed reporting of embodied carbon for all new projects

Integration with existing standards: Align the rating system with existing sustainability certifications (e.g., LEED, BREEAM)

Implementation support

Incentives and regulations

- Financial incentives such as tax rebates or grants with higher star rating
- Implement regulations that mandate minimum embodied carbon performance standards for new construction projects

Training and development

- Raise awareness and conduct trainings for construction professionals about to apply the rating system

Collaboration and innovation

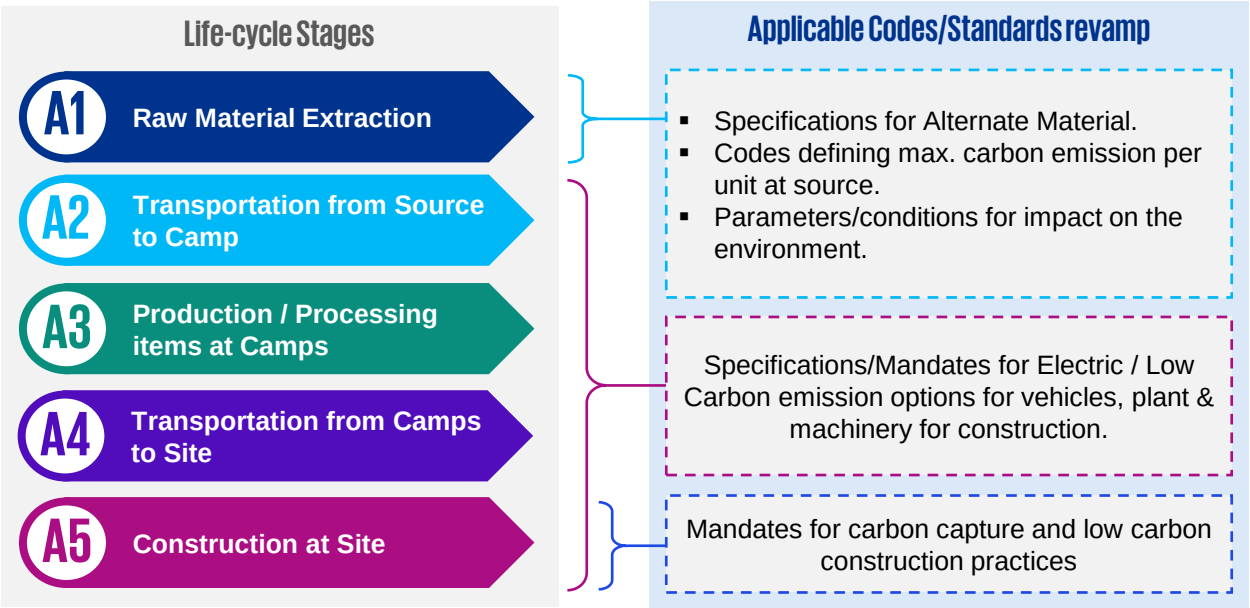
- Encourage collaboration between industry stakeholders to develop innovative low carbon materials and construction techniques

3.2 Codes & Standards revamp

Codes and standards will play a critical role in curbing embodied carbon in the built environment by setting guidelines and requirements for materials, construction practices, and engineering design. They can mandate the use of low-carbon materials, promote energy-efficient construction methods, and encourage the adoption of sustainable building practices. By incorporating measures to reduce embodied carbon into building codes and standards, Government and industry bodies can help minimize the environmental impact of construction activities and promote the development of low carbon buildings.

05 **The existing codes and standards should be revisited for the specified design tolerances/minimum standards and safety limits for achieving design resilience with low carbon options**

Primarily, codes impacting the Lifecycle stages of A1 to A5 need to be revamped with periodic updates to integrate the latest environment friendly techniques and materials



Electric/ Low carbon emitting machinery and equipment are impacting 3 lifecycle stages as depicted above. Despite the notable governmental emphasis on electric vehicles, the electrification of construction equipment and heavy machinery has seen minimal progress. This impedes the industry's transition to greener alternatives, attributed to the high capital investment and potentially lower returns associated with these options.

Additionally, while there are proven instances of successful implementation of alternative and new construction technologies, their widespread proactive adoption is hindered by the absence of government mandates in codes.

Few of the low carbon intensive material lacking standardisation in codes

Glass Fibre Reinforced Polymer (GFRP)

- Suitable substitute for traditional steel rebars.
- Lower life cycle cost.
- ~ 40% fewer CO2 emissions [26].

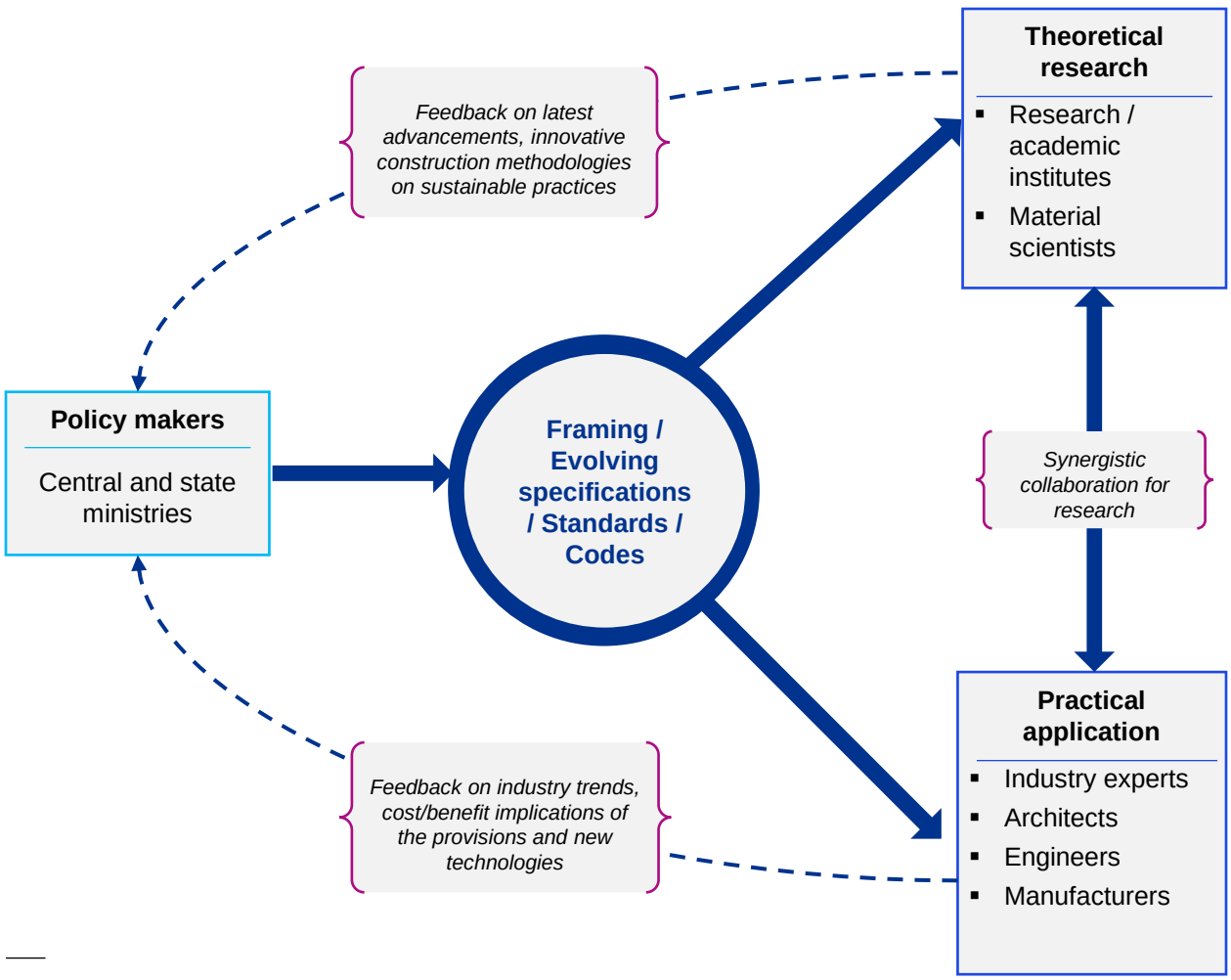
Other alternate materials

- Rice husk for soil stabilisation in earthworks.
- Marble dust as fine aggregate in concrete.
- Foundry sand as filler in concrete mix.

A collective and cohesive approach is paramount to ensuring that the relevant codes and standards remain current with the latest scientific advancements and industry trends. Moreover, their regular reviews and revisions are essential to enable adaptation to changing circumstances and emerging technologies.

Coordinated efforts involving government and industry experts, including architects, engineers, materials scientists, and manufacturers are crucial for research and development of low-carbon technologies and innovative construction methods.

An Indicative Framework for periodical updation of Codes/Standards



26. KPMG in India analysis based on following references:
    - World Steel Organization Sustainability indicators
    - Ministry of Steel Energy & Environment Management in Steel sector
    - UKIERI Concrete Congress & BSRIA guide

04

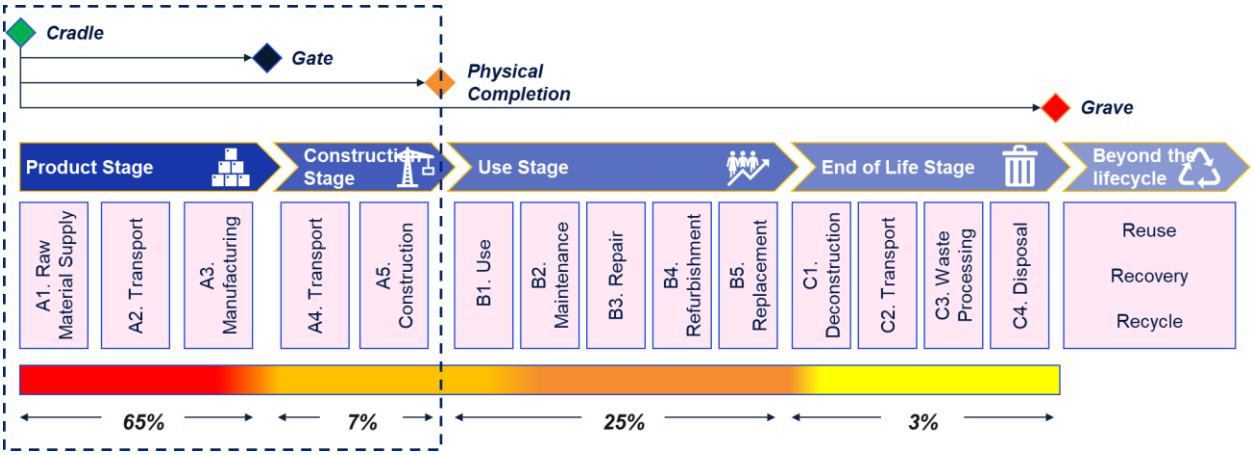
Emission reduction strategies and pathways

30

4.1 How much of the embodied carbon is addressable and when to address it

Challenges with managing the embodied carbon are multifold and it is best addressed at the early stages of any project. Majority of an asset's emissions, about 70% - 80% occur during the project phase with construction material contributing the most, about 90% of the project phase emissions.

Embodied Carbon assessment across Project Lifecycle [27]



Majority of the construction is reliant on two material classes: cement and steel. Emission abatement is a challenge in construction as these are the two most emission intensive materials to manufacture and there are lack of alternatives to these material at scale. Emissions from cement and steel sectors are currently 225[28] and 273[29] mtCO2e respectively. Considering the National Infrastructure Pipeline in India alone, emissions from these materials alone are expected to climb to 322[30] and 659[31] mtCO2e by 2030, making it imperative to focus on their value chain for decarbonization opportunities.

Reduction strategies for embodied carbon can be classified basis multiple factors like potential for reduction, availability/scalability in Indian context, capex required, technological maturity, etc. While there is no dearth of immediately available and deployable methods for reducing the emissions, the industry is held back by the challenges accompanying every solution.

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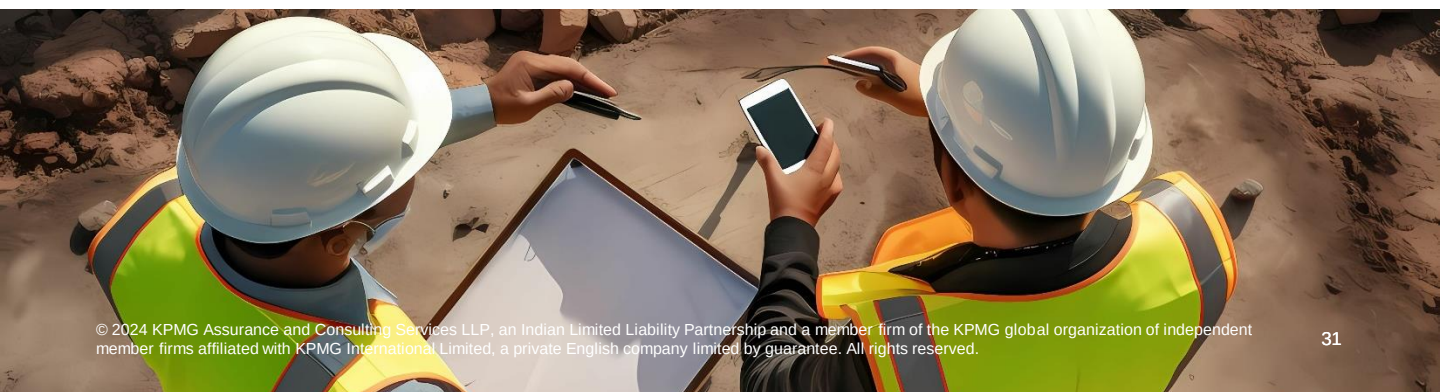
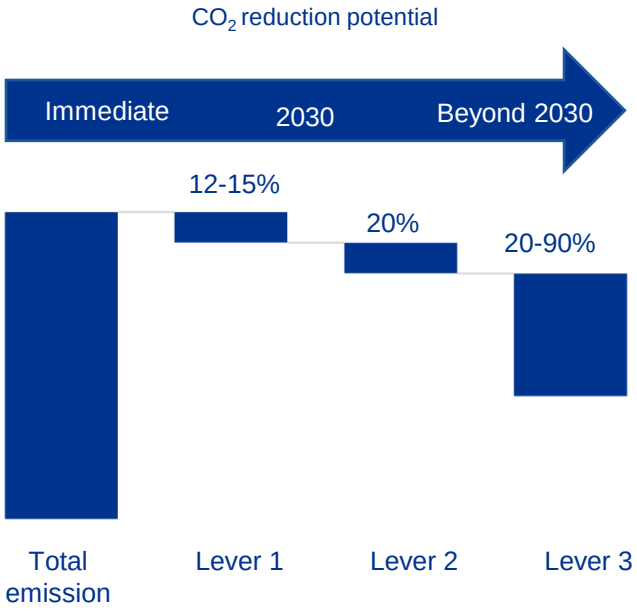
27. Recreated by KPMG in India based on Life Cycle Phases defined in EN 15978:2011Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method
28.
    - Decarbonising India_Cement Sector, CSEindia, Parth Kumar, 2023
    - India: cement CO_2 emissions 1960-2022, Statista, released date Dec 2023
29.
    - Decarbonising India_Iron and Steel Sector, CSEindia, Parth Kumar, 2022
    - Towards a low carbon economy, TERI, Will Hall, Thomas Spencer, Sachin Kumar, 2020
    - Steel Decarbonising in India, IEEFA, Jyoti Gulia, Kapil Gupta, Vibhuti Garg, Shantanu Shrivastava, Sep 2023
30. KPMG in India analysis basis reference from 28, 29 and National Infrastructure Pipeline projections showcased in Annexure
31. KPMG in India analysis basis reference from 28, 29 and National Infrastructure Pipeline projections showcased in Annexure



For ease of understanding, we have identified three broad categorical levers with reduction potential from 15 to 90% of the emissions –

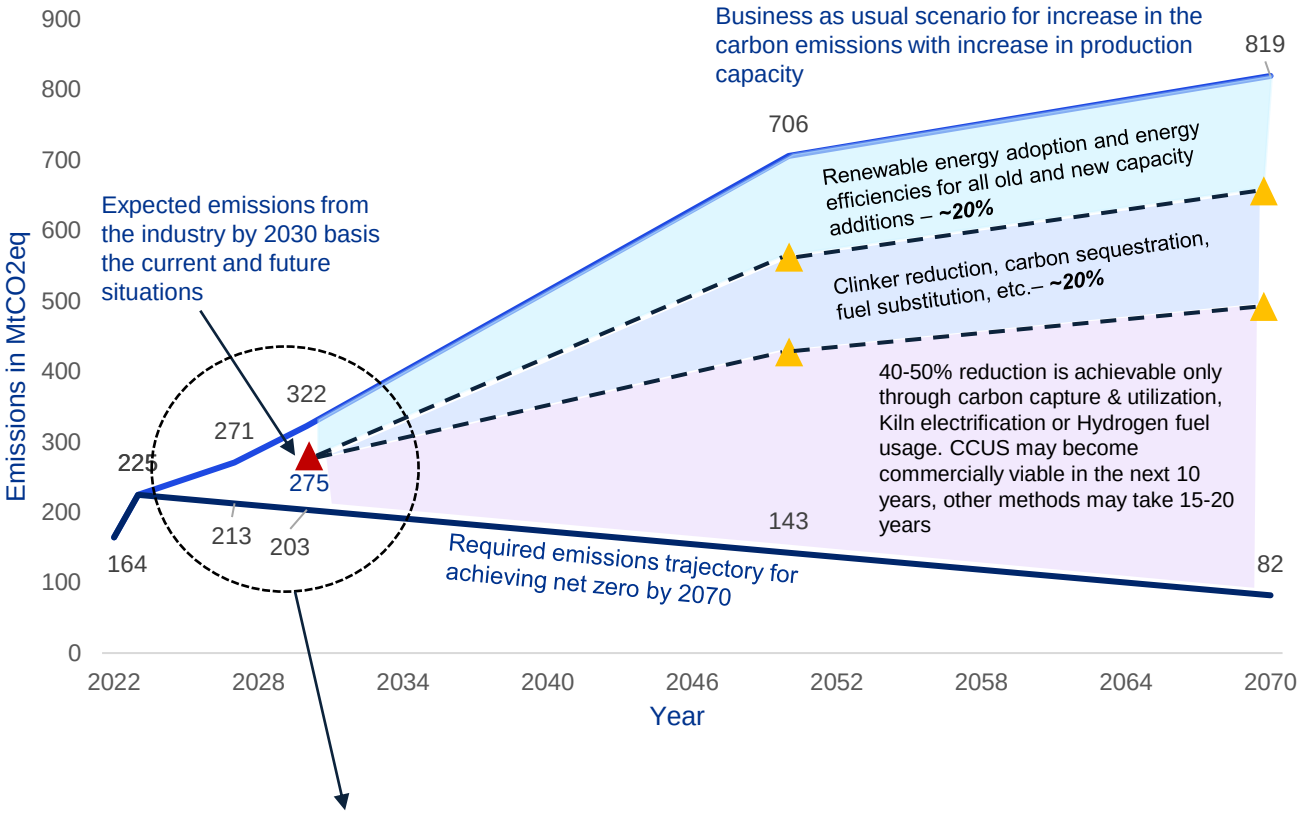
1. Readily available solutions with minimum capex impact, immediate implementation, and scalable
2. Readily available solutions which are yet to be scaled for widespread usage like alternate materials
3. Technologies under trial/pilot implementation and not yet commercially viable

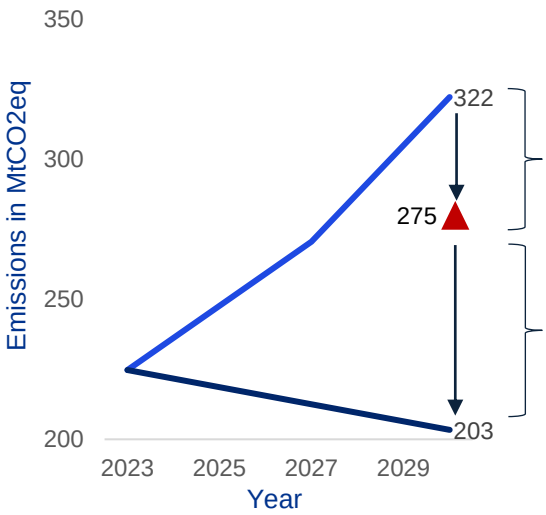
Graph 6:Various levers depicting emission reduction potential [32]



32. KPMG in India's Analysis based on following references:
    - Decarbonising India_Cement Sector, CSEindia, Parth Kumar, 2023
    - Decarbonising India_Iron and Steel Sector, CSEindia, Parth Kumar, 2022
    - Towards a low carbon economy, TERI, Will Hall, Thomas Spencer, Sachin Kumar, 2020
    - Indian Cement Industry Analysis, IBEF 2023
    - Steel Decarbonising in India, IEEFA, Jyoti Gulia, Kapil Gupta, Vibhuti Garg, Shantanu Shrivastava, Sep 2023

Graph 7: Projected emissions and reduction levers in Cement production [33]





15% reduction in emissions expected to be realised at minimum to nil capex

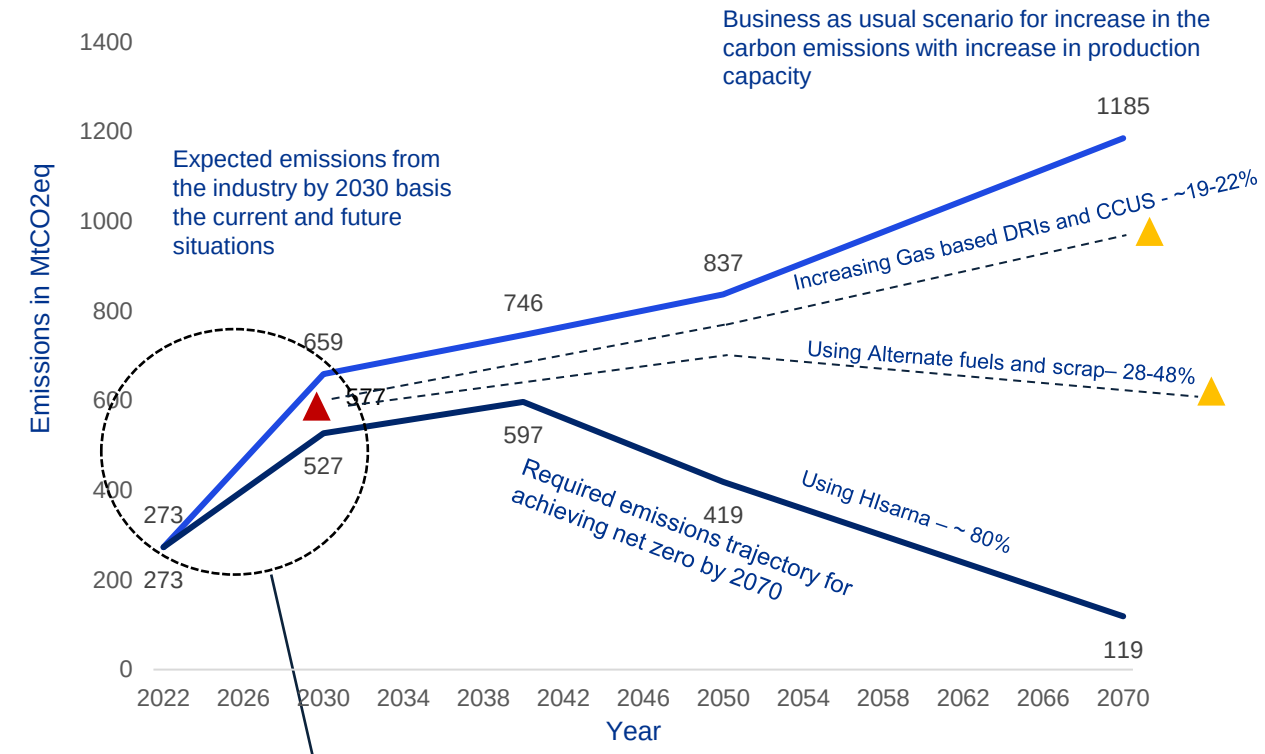
- Improvement in energy efficiency measures including expected capacity doubling of Waste Heat Recovery System (WHRS)
- Increase in renewable power utilisation from 35% to 42% by 2025 and ~60% by 2030
- Clinker reduction through increased utilization of Ground Granulated Blast furnace Slag (GGBS) and Lime calcined clay cement (LC3), carbon sequestration, negative carbon materials

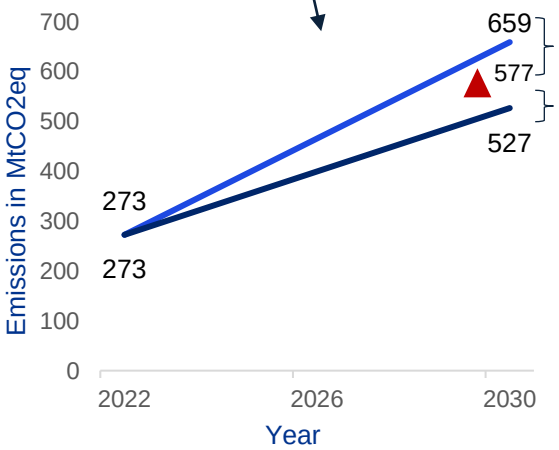
Bridging the Gap – realizing available potential

- Increased conversion to renewable energy sources (only 35%)
- Realize full potential of energy efficiency measures in cement plants and expedite WHRS deployment (~50% WHRS potential utilized)
- Popularize supplementary cementitious materials like GGBS and LC3 – GGBS production stands at 15MnT currently, 50-70% clinker substitution potential
- Adopt carbon sequestration methods through technologies like carbon cure – 5-6% cement reduction potential in concrete

33. KPMG in India's Analysis based on following references:
    - Decarbonising India_Cement Sector, CSEindia, Parth Kumar, 2023
    - Indian Cement Industry Analysis, IBEF 2023
    - India: cement CO_2 emissions 1960-2022, Statista, Dec 2023

Graph 8: Projected emissions and reduction levers in Steel production [34]



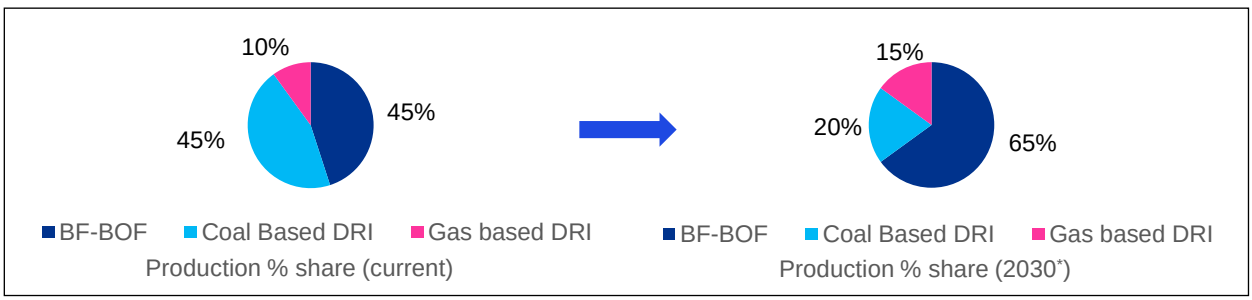


~12% reduction in emissions expected to be realized at minimum to nil capex

- Increase Blast Furnace (BF) - Basic Oxygen Furnace (BOF) route % share from 45% to 65%
- Increase in gas based Direct Reduced Iron (DRI) share from 10 % to 15 %

Bridging the gap – realising available potential

- 30 % CCU used in BF-BOF route
- Voluntary declaration in emission factor (~1.8-2.2 tCO2) by major steel players

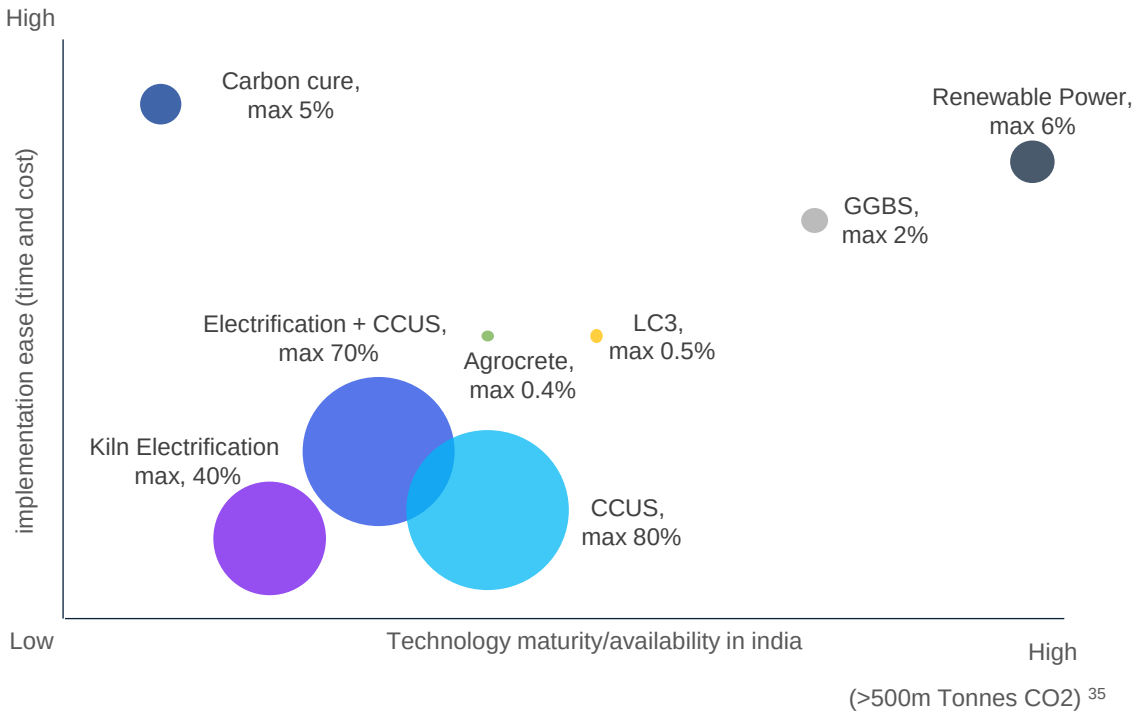


*owing to leading steel player capacity announcement

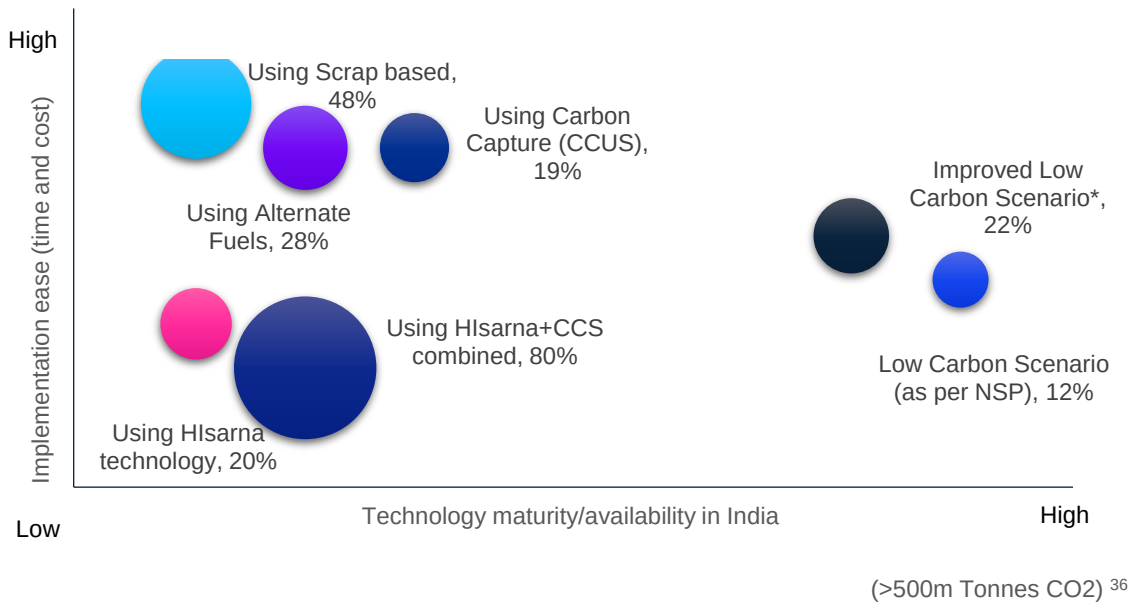
34. KPMG in India's Analysis based on following references:
    - Decarbonising India_Iron and Steel Sector, CSEindia, Parth Kumar, 2022
    - Towards a low carbon economy, TERI, Will Hall, Thomas Spencer, Sachin Kumar, 2020
    - Steel Decarbonising in India, IEEFA, Jyoti Gulia, Kapil Gupta, Vibhuti Garg, Shantanu Shrivastava, Sep 2023

4.2 Emission reduction levers implementation ease vis-à-vis technology maturity in India production

Graph 9: Solution for reducing CO2 emissions from cement production



Graph 10: Solution for reducing CO2 emissions from steel production



35. KPMG in India analysis based on following references covered in 33
36. KPMG in India analysis based on following references covered in 34

4.3 Key Considerations for decarbonisation strategies

While operational carbon is being constantly optimised by increasing efficiency and the increasing spread and utlisation of renewable energy, embodied carbon is much more complicated to address.

A few case studies addressing embodied carbon and the key considerations while addressing them are:

SN	Strategy	Pilot Project	LC Intervention Stage	Key considerations
1	Designing for low carbon	Optimizing cement content in concrete mix design	Design Stage	Reduce cement content by revisiting existing mix design while maintaining the desired compressive strength as per drawing
2	Design Optimization Strategy	Use of Cement treated base and sub base layer instead of conventional carbon intensive WMM layer	Design Stage	Use of alternate materials in place of traditional materials of construction
3	Supply chain optimization	A leading Steel producer using inland waterways to transport machinery	Procurement and Logistics	Leveraging alternate low carbon means of transporting project material
4	Alternate fuel usage	A leading Steel producer using LNG-Fueled trailers	Logistics and Supply Chain	Use of low carbon fuel for transportation of finished goods
5	Alternate material strategy	India's first Steel Slag Road using 100% processed steel slag aggregates	Design Stage	Use of alternate materials in place of traditional materials of construction
6	Alternate material strategy	Use of FSC certified timbers for mounting Solar Panels	Design Stage	Use of alternate materials in place of traditional materials of construction

Reduction and mitigation of embodied carbon first require measuring and identifying carbon hotspots across the construction material value chain. Transparency and availability of data play a crucial role to measure and manage embodied carbon and the evolving technology landscape can serve as the key enabler in this respect.

4.4 Technology & Digital Intervention

The introduction of new codes and standards to report emissions in projects, public commitments by asset owners and requirements in building certifications have catalyzed the development of a wide variety of tools and platforms to measure and manage embodied carbon in the built sector.

The currently available tools range from parametric upfront embodied carbon measurement to leveraging building information modeling for whole-life carbon analysis.

KPMG's Embodied Carbon Management System is one such platform which leverages Building Information Modeling (BIM), seamlessly integrating design, material and supply chain data with carbon factors, environmental product declarations and transportation data. Multi-scenario assessments powered by visualization of carbon hotspots, alternate low-carbon material suggestions with cost trade-offs for high-emission materials assist stakeholders to take key decisions across the construction lifecycle to decarbonise their projects and portfolios.

KPMG Embodied Carbon Management System aims to add value across the lifecycle of an asset:

Investment / pre-planning

- Project investment assessment for carbon ownership
- Parametric carbon benchmarking

Design & planning

- Carbon hotspots and project carbon critical path
- Low carbon design strategies
- Alternative materials assessment

Procurement & supply chain

- Multi-scenario analysis for low carbon design
- Carbon traceability in supply chain

Construction

- Carbon simulation across construction life-cycle
- Scope-wise emission analysis

Commissioning & operations handover

- As-built carbon modeling
- Areas for embodied carbon reduction during O&M

4.5 How AI can accelerate the change

The currently available tools range from parametric upfront embodied carbon measurement to leveraging building information modeling for whole-life carbon analysis. The advancements in the field of artificial intelligence have opened more avenues for efficiently and accurately addressing

Innovation and R&D
Identify trends and insights from large datasets that can drive innovation in low carbon materials, technologies and development of sustainable options

Data collection and processing
Automate collection and processing of large amount of data (supply chain, production process, etc.)

Predictive analytics
Analyse historical data and predict footprints of new products / processes

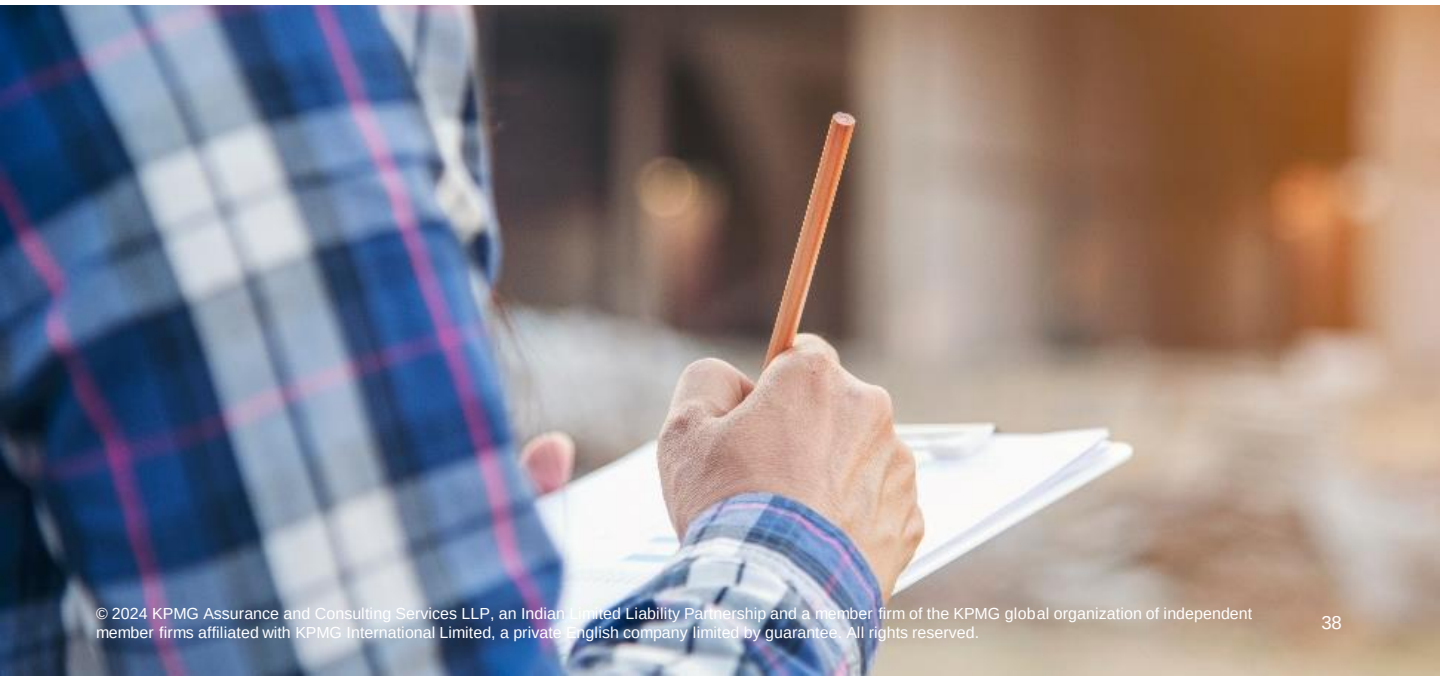
Transparency and reporting
Improve transparency and accuracy of carbon reporting through automation of data validation and verification

Supply chain optimisation
Optimise supply chain for carbon reduction (identify sustainable suppliers, optimised transportation route

Natural language processing
Help extract relevant carbon data from unstructured sources (scientific papers, reports, regulations etc.)

Decision support tools
Real-time feedback and support to architects and engineers for choosing low carbon design and material

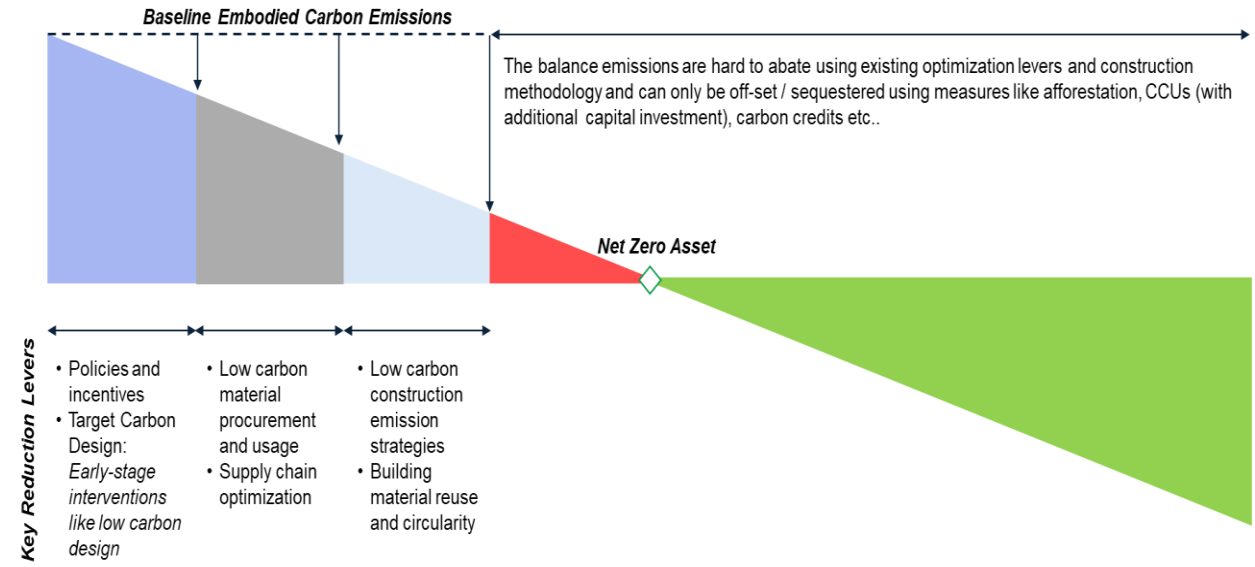
Scenario analysis
Assess potential impacts of multiple combination of materials, processes and supply chain



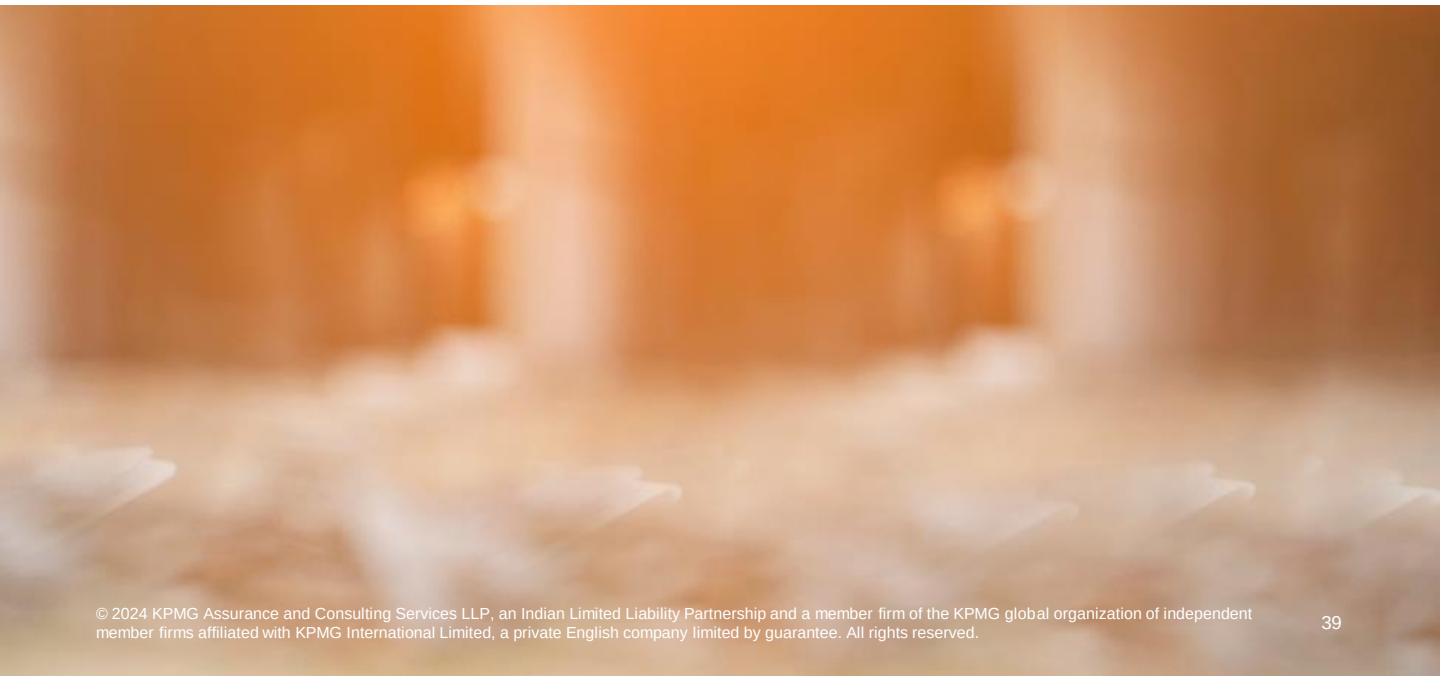
4.6 Debunking the net zero myth in construction without embodied carbon

While efforts have picked in addressing embodied carbon with technology being a key factor in the fight against such emissions, achieving a completely net zero asset remains an aspiration at large.

Net Zero: Embodied Carbon Asset	Net Zero: Operational Carbon Asset	Total Carbon Net Zero Asset
Extremely challenging without offset or sequestration efforts	*Conventional focus area and continuous efforts are in place to decarbonise further*	*Possible to achieve but requires upfront emission reduction*



Unless focused from the earliest stages, embodied emissions can potentially rise exponentially, leaving little to no scope for reduction in later stages of an asset. Stakeholders will then have to rely on external interventions like afforestation and building and deploying CCU methods for their asset to achieve.



Annexure

India has embarked on a journey to provide world-class Infrastructure to its citizens through the launch of the National Infrastructure Pipeline programme (NIP) attracting more than USD 1,900 BN.[37,38]

Sectors	Sub Sectors	Investment Expected in the next 4-5 years in USD BN
Energy	Electricity Transmission & Distribution	119
	Energy Generation- Non-Renwable	111
	Energy Generation-Renwable	210
	Oil/Gas/Refinery Expansion	75
	Total	515
Industrial Infrastructure	Cement Plants*	114
	Steel Plants **	504
	Total	618
Social Infrastructure	Educational	34
	Housing	162
	Irrigation	155
	Medical	26
	Total	377
Transport	Airport	21
	Roads	404
	Urban Public	75
	Total	500
Grand Total		**2010**

*Cement Capacity addition expected in the next 4-5 years [39]

Current Capacity	576.40	MMTPA
Capacity FY 2027	724.8236	MMPTA
Delta	148.42	MMPTA
Capex Required	94991.11	INR CR
Capex Required (USDBN)	114	USDBN

**Steel Capacity addition expected in the next 4-5 years[40]

	Capex Spent (INRCR)	MTPA Addition	Per MTPA Cost	Split of 150MTPA	Total Capex	Total Capex in USDBN
Greenfield	20000^	5	4000	30	120000	144
Brownfield	8000^	3.2	2500	120	300000	360

37. Capital expenditure outlay for 2022-23 increased sharply by 35.4 %, Press Information Bureau, Ministry of Finance, January 2023
38. National Infrastructure Pipeline: Invest in Infrastructure Projects in India | India Investment Grid, Ministry of Commerce and Industry, June 2023
39. Indian Cement Industry Analysis, Indian Brand Equity Foundation, June 2023
40. Indian Steel Industry Analysis, Indian Brand Equity Foundation, June 2023

Acknowledgment

We are extremely grateful to senior leaders/subject matter experts from the industry, quoted in the report and KPMG in India team members for extending their knowledge and insights to develop this report.

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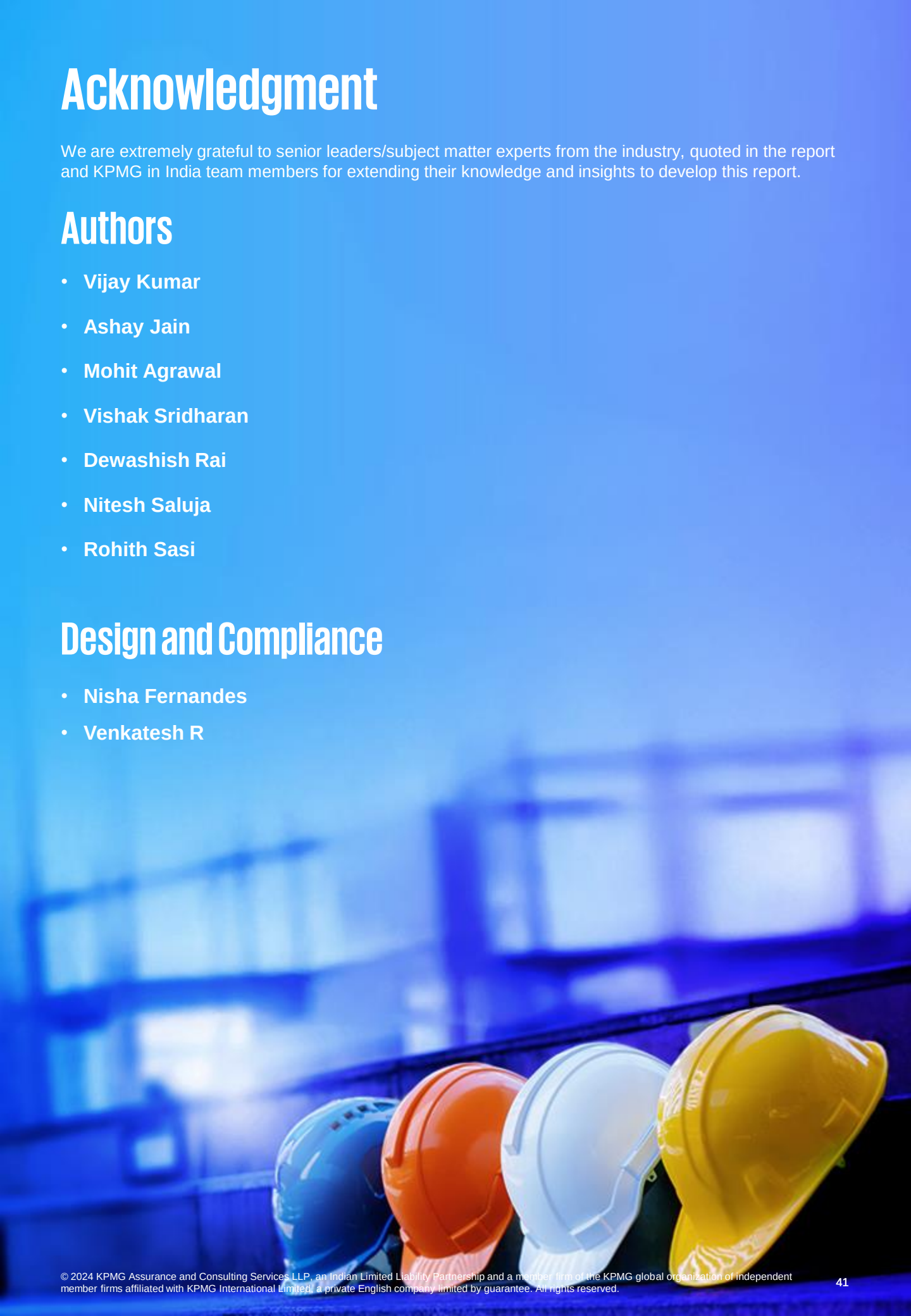

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